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THE UNITED STATES ISTHMIAN CANAL COMMISSION, appointed by President McKinley, has sailed for Greytown to commence its inspection of all the routes proposed for a ship canal across the Central American isthmus, and to determine the most practicable and feasible route. As before stated, this commission is made up of Admiral Walker, U.S.N.; Gen. Peter Hains, and Gen. O. H. Ernst, U.S.A.; U. S. Senator Pasco of Florida, George S. Morison, M. Am. Soc. C. E.; Alfred Noble, M. Am. Soc. C. E., of Chicago; Prof. W. H. Burr, M. Am. Soc. C. E., of Columbia College; Prof. L. M. Haupt, M. Am. C. E., late of the University of Pennsylvania, and Prof. Emory R. Johnson, now of that institution.

TRAFFIC THROUGH THE SAULT CANALS for the four years, 1869, 1879, 1889 and 1899, is given in a bulletin just issued by the Treasury Bureau of Statistics as follows:

	1869.	1879.	1889.	1899.
Vessels	1,338	3,121	9,579	20,255
Tonnage	524,885	1,677,071	7,221,935	21,958,347
Wheat, bush.	*49,700	2,603,666	16,231,854	58,397,335
Other grain, bush.	323,501	951,496	2,133,245	30,000,935
Flour, bbls.	32,007	451,000	2,228,707	7,114,147
Iron ore, tons	239,398	540,075	4,095,855	15,328,240
Copper, tons	18,662	22,909	33,456	120,090
Coal, tons	27,850	110,704	1,629,197	3,940,887
Lumber, M. ft.	1,200	35,598	315,554	1,038,057
Passengers	17,057	18,579	25,712	49,082

*1870.

THE NEW EAST RIVER BRIDGE at New York city has made substantial progress toward completion during the year ending Dec. 31, 1899. On Feb. 21, 1899, the contract for the construction of the steel towers and end spans (Eng. News, Feb. 17, 1898), was let to the New Jersey Steel & Iron Co., of Trenton, N. J., for $1,220,230, and work is now in active progress. On Dec. 9, 1899, the contract for the construction of the steel cables, suspenders, etc. (Eng. News, Nov. 23, 1899), was let to the John A. Roebling Sons Co., of Trenton, N. J., for $1,398,000. This contract is now awaiting approval by the City Comptroller. Since the organization of the commission in August, 1895, to Dec. 31, 1898, its total receipts from the sale of bonds had been $3,188,580, and its total expenditures $2,354,067.63, leaving a balance at the beginning of 1899 of $834,512.37. At the end of 1898 the commission had obligated itself by contract to the extent of $2,399,593.46, on which payments had been made to the extent of $1,112,333.66, leaving the balance of contract indebtedness at $1,287,259.80. Since the end of the year 1898, bonds have been authorized by the Board of Estimate to bring the total of the bonds authorized for the uses of the East River Bridge Commission up to $9,562,473.66. The total proceeds received from bonds sold up to Dec. 31, 1898, amount to $5,255,148.16.

SEVERAL NEW EAST RIVER BRIDGE AND TUNNEL schemes have developed during the last week. On Jan. 4 the Terminal R. R. & Tunnel Co. was incorporated at Albany, N. Y., with a capital of $50,000, to build a tunnel from "a loop terminus at Prospect Park, past the Long Island R. R. station and the city hall in Brooklyn via James Slip to the city hall in Manhattan, and thence along Park Place to a point near the Pennsylvania R. R. station in Jersey City, with spurs north and south to the Erie R. R. and Central R. R. of New Jersey stations." Among the incorporators of the company are Arthur C. Hume of 18 Wall St., and David L. Hough, of 15 Park Row, New York city, both of whom have been interested in similar rapid transit and tunnel schemes in the past. The current newspaper rumor is that the real backers of the scheme are prominent capitalists and politicians. On Jan. 3 a bill was introduced in the New York state legislature providing for the appointment by the Governor of a commission consisting of three citizens of the city of New York, together with the President of the Borough of Manhattan and the person now occupying the office of President of the Borough of Queens, for the purpose of constructing, as agents of the state, a permanent cantilever bridge over the East River. The bridge is to be adapted for the use of street surface, elevated road cars, trucks, carriages, bicycles and foot passengers, and is to be constructed across the East River from Manhattan Borough to the Borough of Queens over Blackwell's Island. Assemblyman Brennan, of New York, has announced his intention of introducing at once in the state legislature a bill creating a state commission to build a bridge across the East River between the navy yard and the present Brooklyn Bridge; (2) a bill providing for the construction of a tunnel from the Battery in Manhattan to Hamilton Ave., in South Brooklyn, and (3) a bill to build either a tunnel or a bridge from Manhattan to Queens at Blackwell's Island. During the week also, Comptroller Coler of New York city has enlarged the plan of his fight to substitute tunnels for bridges for crossing the East River, which was reviewed in our last two issues. The latest move of the Comptroller is to address a request to the Rapid Transit Commission asking that their plans for an underground railway lengthwise of Manhattan Island be enlarged so as to include the construction of one or more connecting tunnels under the East River to Brooklyn.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Chesapeake & Ohio R. R., at Clifton Forge, Va., on Dec. 29. The engineman and two other trainmen of a freight train were asphyxiated in the tunnel at that place.——The explosion of a locomotive on the Denver & Rio Grande R. R., at Minturn, Colo., on Dec. 27, resulted in the death of two men.

A NEW TREATMENT FOR TUBERCULOSIS has been developed by Dr. Mendel, of Roubaix, France, and is described at length in the January issue of "Consular Reports." It consists in the injection of certain essential oils into the trachea. The solution used is made up of 100 cu. cm. of sterilized olive oil, to which is added 5 grams each of the essential oils of thyme, eucalyptus and cinnamon. From 9 to 12 cu. cm. are injected daily into the tracheal duct by a curved syringe. On Sept. 9, Dr. Mendel had treated 27 tubercular patients by this system with results which thus far appear to be notably beneficial especially in the case of patients in the earlier stages of the disease. The theory of the treatment is based on the experiments which show that the vapors of the essential oils used have a powerful antiseptic effect on tubercular germs. Copies of the issue of "Consular Reports" containing a full account of the treatment can be obtained by addressing the Bureau of Foreign Commerce, State Department, Washington, D. C.

THE PARTIAL ABOLITION OF WATER RATES AT Detroit has received its final blow by a decision of the State Supreme Court that the act under which this was to be done is unconstitutional. The plan was described and discussed at length in our issue of June 29, 1899. The act in question provided for the transfer of the works from the Water Board to the Board of Public Works and also for various changes in the methods employed to raise money to operate the plant. The most important of these changes was the abolition of all charges for water used for domestic purposes, and for water closets and wash rooms in buildings not used as residences. A lower court declared the act unconstitutional, as stated in our issue of Aug. 3, 1899. The Supreme Court takes the same attitude, holding that the object of the act was only partially set forth in its title, which related to a change in he control of the works, whereas the act also lays down a new scheme of taxation; it also holds that the act deals with questions of local taxation, which cannot be decided by the legislature without the consent of the voters of the city.

WASTE OF WATER BY LEAKAGE IN MAINS is commented upon by Mr. James C. Bayles in a letter to the New York "Tribune." His first remark is that the city's engineers will not tell how much water is wasted by leaks in the distribution system—or, what is more probable, they make no effort to find out. The fact is, that water enough for the use and waste of a population of 10,000,000 is found insufficient for the daily requirements of about 2,000,000 people. Ex-Water Register C. O. Johnson estimated the present daily waste at 36,000,000 gallons. George F. Deacon, the eminent English engineer, says that, on the average, more water leaks from pipes, joints and fittings than is used or wasted by the consumer; and he has made a study of this subject that is exhaustive and standard. Mr. William Hope, in a paper presented to the Institution of Civil Engineers, claims that a majority of water supply companies lose by leakage one-half of the total quantity obtained from the source; and in many cases this proportion is exceeded. The gist of Mr. Bayles remarks is that some intelligent attempt should be made to check this waste in New York, before setting out to spend millions to obtain further quantities of water to waste. Although difficult to determine the actual amount of leakage it is by no means impossible to locate the worst of it; and it might be advisable to relay a large part of the distribution system of the city rather than have such heavy wastes continue.

THE NORTHWESTERN ELEVATED R. R., at Chicago, has been practically completed, though the stations, interlocking plant, etc., are not yet ready for service. One train a day is run daily to keep the franchise, but the city holds that as the road was not completed by Jan. 1, the $100,000 guarantee furnished by the company when the time for completion was extended to Jan. 1, 1900, must be forfeited. New arrangements have been made between the city and the company, under which the latter agrees to light street crossings and do other auxiliary work demanded by the city.

GRADED FARES FOR STREET RAILWAY service have been introduced by the Chicago General Ry., which operates 30 miles of electric lines in the suburban and outlying districts of Chicago. This is a substitute for the ordinary uniform fare of 5 cts., and Mr. Charles L. Bonney, Vice-President of the company, informs us that the system is found to be very satisfactory to the company and to the people, and he believes it could be adopted by all the surface lines in Chicago, with advantage to themselves and their passengers. The cash fares are 5 and 10 cts.; the fares by ticket range from 2 to 7½ cts. The maximum distances are 7 miles for 10-ct. and 7½-ct. fares; 6 miles for the 5-ct. and 3½-ct. fares; and 3 miles for the 2-ct. fares. The schedule of fares which went into effect Jan. 1 is as follows, and it will be seen that the reduced fares are obtained only by the use of tickets, which are purchased in quantities:

Between Stock Yds. and Drainage Canal,	cash fare.	10 cts.
" " " "	by ticket.	7½ "
Between any two lines, with transfer,	cash fare...	5 "
On any one line, without transfer,	cash fare.....	5 "
On 22d St. line, by ticket.....		3½ "
On Stock Yards, Ashland Ave., Rockwell St., Kedzie Ave., Laundale or 25th St. lines, by ticket...		2 "

IRON ORE RECEIPTS at Lake Erie ports in 1899, exceeded those of any previous year. Ashtabula reports 3,759,615 tons; Cleveland, 3,662,137 tons; Conneaut, the new Carnegie harbor, reports 2,599,180 tons; Lorain, 1,212,301 tons, and Fairport received 1,398,811 tons. This is a total of 12,632,044 tons. The coal shipments for the last season were also large. Cleveland leads with 1,856,425 tons; Ashtabula, 1,151,746 tons; Fairport, 203,228 tons, and Conneaut, 115,039 tons.

A NEW STEEL PLANT, says the Buffalo "Courier," is to be established on Squaw Island, at Buffalo. The capitalists who bought the 175 acres of islands for $700,000 are unnamed, but are said to be from New York and Philadelphia. Judging from the form in which the news comes the project is still somewhat in the air; though the item speaks of millions to be expended in furnaces a nd steel mills, docks, and storehouses for handling freight in transit from steamers to railways. Mr. Thomas M. Ryan, of Buffalo, is interested.

THE PRESERVATION OF THE PALISADES can be secured, reports the New Jersey Commission, by the enactment of a law forbidding the granting of any further riparian rights along the strip to be protected. The state of New Jersey now controls this right on nine out of the twelve miles of the Palisade front, from Fort Lee to the New York state line. The Commission also recommends the appointment of a permanent commission, which can hold, purchase and take charge of and improve the lands devoted to protective purposes. At the present time the ease with which this stone can be quarried and shipped offers a tempting invitation for further destruction of these picturesque rocks. Gov. Roosevelt approves of this course, and strongly advocates joint action with New Jersey in abolishing further grant of riparian rights.

A SHORTAGE IN THE ENGLISH COAL SUPPLY is following an unprecedented traffic demand upon the English railways, which are compelled to give precedence to passenger trains and light and perishable goods over minerals. The two months preceding Christmas saw such an increase in the carrying business that the railways were unable to cope with it; and as a consequence, the colliery sidings are full of loaded cars, awaiting transportation; and at Sheffield and other places works are being shut down for the want of this coal. The growing scarcity of coal itself is adding to the trouble. South Russia is also suffering from the increase of factories and the shortage in the English supply of coal. The Donetz Russian coal is of inferior quality, but in eight years the consumption of this coal by local works has increased from 19,000 to 200,000 car-loads. When the store of English coal at Odessa is exhausted many of the factories will have to shut down.

SUPPORTS FOR BEAMS IN TESTS OF TRANSVERSE STRENGTH.*

By Wm. T. Magruder,† M. Am. Soc. M. E.

When the Ohio State University purchased its 100,000-pound Olsen automatic and autographic testing machine, nothing was specified as to the details of the supports for beams in tests of transverse strength; and when the machine was received in February, 1897, two cast-iron supports ("G," Fig. 1) accompanied it. They have a piece of bar steel showing an edge ¼ × 4 ins., cast in their upper or bearing surface, and this is shaped to a convex curve of ⅛-in. radius. A boss is provided in the base, but no hole in the boss whereby the supports might be bolted down if that should in the future prove to be desirable. On the contrary, the inner foot of these supports was shaped to a convex curve of a radius equal apparently to the height of the support, so as to allow them to roll towards each other when the deflection of the test beam was such as to induce such a motion. This would of course preclude the use of holding down bolts. It was found in practice that the radius of curvature of the upper surface was too great, and also that instead of the test beams causing the supports to roll towards each other gradually as the beam deflected, they either stayed as placed, or else moved apart and by jumps intermittently; when they did so the span was increased correspondingly.

The subject of fixed supports, which should be either rigid or else flexible, was taken up by the writer with the following results: (F), Fig. 1, represents a fixed and rigid support, capable of being bolted to the compound I-beam (A), made with a flat sole and having an upper supporting surface made of a piece of tool steel hardened and ground to ⅛-in. diameter and resting in a groove cut with a ⅛-in. convex milling cutter. For a rigid support this seems to fill our needs and is thought to be an improvement over (G).

For a flexible support, (B) (C) was designed and made. It consists of a piece of No. 8 or No. 10 saw-plate steel fastened by ½-in. bolts into recesses cut into one of the legs of the 3 × 4-in. and 3 × 3-in. heavy angle irons forming the base and top respectively. It is provided with bolt holes so that it may be fastened to the supporting I-beam. The apex of the upper angle iron is chamfered off so that the supporting edge shall be exactly above the center of the flexible plate. The angle irons are reversible, so that there are four possibilities as to arrangement. It is thought that with the two supports made up in Z fashion, with the lower angle irons on the inside, that we get nearer to actual practice than we do when using either (F) or (G). So far we have not had occasion to load these to over 15,000 lbs. each, but we believe that with metal of the proper thickness and temper no difficulty would be occasioned in their use with larger loads.

While, in the use of (B), the desired flexibility was secured, yet it took force to deflect them which decreased the fiber stress on the tensile side of the beam; neither were they frictionless. To secure this latter end, the supports (B) and (F) of Fig. 2 were designed. They consist of cast-iron supports (B) and (B¹), in whose upper side-supports concave grooves are milled, carrying pieces of ½-in. round tool steel, hardened and ground. On these pieces (C) rest the hardened steel pieces (T) of the cradle (F). The pieces (T) have been ground to one true plane on their under side parallel to the bottom of the cradle and so that the cradle can rock on the pieces (C) of the carriages or supports (B). The cradles (F) are made of 1⅛ × 4-in., 70,000-lb. bridge steel, bent to a U-shape, so as to carry one end of the test beam. The beam rests on the top of height-blocks (G), (H) or (I), which rest on a ¼ × 2-in. hardened steel upper plate moving freely on ten ½-in. steel balls rolling on a ¼ × 2-in. hardened steel lower plate, which rests in the bottom of the cradle. By this means, the beam is free to slide longitudinally on the ball bearings in its cradles, which experience shows it is not loth to do, and at the same time is free to rotate about the center of (C) as an axis. Furthermore, by using height-blocks of proper heights, the true center line of support for the beam can be made to pass through any point in the beam. For example, with (I), the center line through (C) passes through the bottom plane of the beam, while with (H) it passes through the center of a beam 4 ins. deep, and with (G) it passes through the top plane of the same beam.

It is of course necessary to block up with wedges the steel plates and to cage the balls, so as to prevent their sliding off before the load is put upon the beam. These wedges are subsequently removed so as to allow untrammelled freedom of motion of the beam in the cradles. To prevent the cradle jumping out of its carriage at the time of rupture when such materials as cast-iron are tested, horseshoe-shaped guards are used. The steel plates and ten-ball ball-bearings have been tested to their maximum capacity with this machine, namely, 50,000 lbs., and found to receive no indentation. With both (F) and (B) (C), the beam may be supported on ball-bearings between the beam and the support to decrease the frictional resistance. So far, these three kinds of supports have worked with satisfaction.

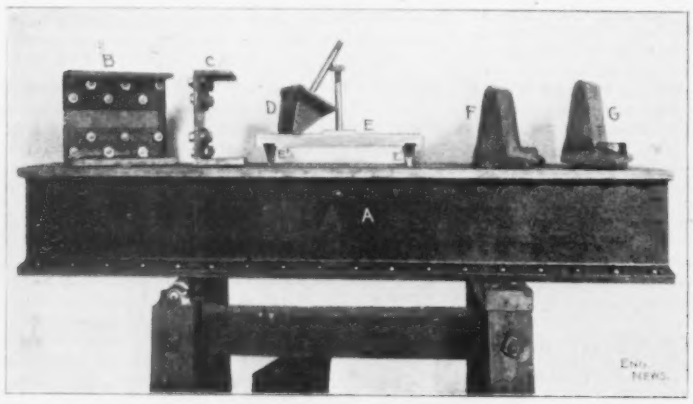

FIG. 1.—SUPPORTS FOR BEAMS IN TESTS OF TRANSVERSE STRENGTH.

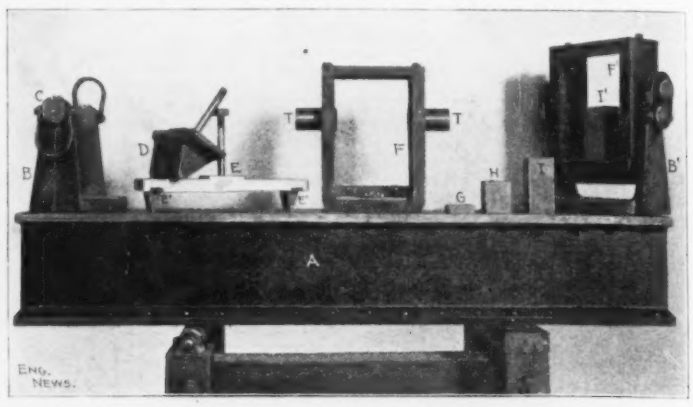

FIG. 2.—BALL-BEARING AND ROLLING SUPPORT FOR BEAMS IN TRANSVERSE TESTING MACHINE, OHIO STATE UNIVERSITY.

*A paper presented at the 48th annual meeting of the American Association for the Advancement of Science.

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LIST OF ORDINANCE FOR GRADE CROSSING REMOVAL IN CHICAGO.

Track Elevation.

Date of ordinance.	Railway.	Track—Main, miles.	Track—Other, miles.	Track—Total, miles.	Number—Of sub-ways.	Number—G. cross. elim.
May 23, 1892	Illinois Central	21.15	.....	21.15	17	19
July 9, 1894	Chicago, Rock Island & Pacific	20.86	15.16	36.02	37	47
" "	Lake Shore & Michigan Southern	18.74	13.30	32.04	32	2
Feb. 18, 1895	Chicago & North Western (Gal. Div.)	12.71	5.58	18.29	7	20
Mar. 30, 1896	" " " (Wis. Div.)	13.28	2.50	15.78	26	48
" "	" " " (Mil. Div.)	11.25	.60	11.85	20	33
July 27, 1896	Pitts., Fort. Wayne & Chic.	10.00	10.16	10.16	13	17
Jan. 18, 1897	Chicago & North Western (Rock St.)	5.64	1.20	6.84	19	22
" "	Pitts., Fort Wayne & Chic. (Rock St.)	4.29	1.08	5.37	19	..
" "	Chicago Terminal Transfer	1.74	.24	1.98	2	3
" "	Pittsburg, Fort Wayne & Chicago	4.25	.54	4.79	2	6
" "	Lake Shore & Michigan Southern	2.12	10.15	12.27	2	..
May 17, 1897	Illinois Central (St. C. A. Line)	4.58	.23	4.81	10	12
Dec. 29, 1897	Chicago & North W'n (Chic. Ave. Div.)	11.82	17.98	29.80	22	41
" "	Chic., Mil. & St. P. (Council Bluff Div.)	.66	1.48	2.14	3	3
Jan. 17, 1898	Chicago, Rock Island & Pacific	2.84	...	2.84	7	10
Jan. 24, 1898	Chicago, Burlington & Quincy	8.33	1.13	9.46	16	30
Feb. 21, 1898	Chic., Mil. & St. Paul (Chic. Div.)	8.17	2.55	10.72	26	43
" "	Chicago & North Western (Mayfair)	.70	...	.70	2	2
Apr. 6, 1898	Chicago Belt	1.35	...	1.35	10	10
May 1, 1899	Atch., T. & S. F. (west from Bridge)	4.00	...	4.00	2	11
" "	Chic., M. & Nor. " "	4.00	...	4.00	2	..
May 22, 1899	Atch., T. & S. F. (west from 18th St.)	5.12	1.66	6.78	19	26
" "	Chic., M. & Nor. " "	5.12	.30	5.42	19	..
" "	Chicago & Alton " "	10.14	11.04	21.18	32	23
" "	U. S. Y. & T. (I. & M. Canal South)	1.79	.53	2.32	6	..
" "	Chic. T. Transf. (I. & M. Canal South)	1.79	...	1.79	6	..
" "	P., C., C. & St. L. (I. & M. Canal South)	1.79	1.15	2.94	7	..
Oct. 23, 1899	Pittsburg, Fort Wayne & Chic.	15.98	22.73	38.71	29	44
" "	Pitts., Cin., Chic. & St. Louis	.68	.50	1.18	6	6
" "	Chicago & Western Indiana	26.61	35.57	62.18	48	22
" "	Chicago & Grand Trunk	.68	...	.68	3	3
" "	Union Stock Yards & Transit	.68	...	.68	3	..
	Total	242.86	157.36	400.22	474	511
	Track Depression.					
.....	Illinois Central	50.24	...	50.24	..	38
Feb. 15, 1897	Union Stock Yards & Transfer	.61	...	.61	..	..
May 17, 1897	Atchison, Topeka & Santa Fe	1.06	1.12	2.18	..	..
" "	Chicago & Western Indiana	2.28	2.97	5.25	..	..
	Total	54.19	4.09	58.28	..	38
	Grand Total	297.05	161.45	458.50	474	549

TRACK ELEVATION IN CHICAGO.

I.

The grade crossing problem has been probably more complicated and more troublesome in Chicago than in any other city in the United States, but since the definite adoption of a track elevation policy in 1893, great progress has been made in removing the tracks from the street level, and the completion of the most important part of the work is now within sight. We have from time to time informed our readers as to the negotiations between the city authorities and the railway companies, and have described individual pieces of work of track elevation, and in another column we have commented editorially upon the progress and present status of the work. In the present article we propose to describe the extent of the work done by the several railways involved, and to describe their different methods of carrying on the work. The information has been obtained from the engineers, and also from papers on this subject published in the "Journal of the Western Society of Engineers" for October and December, 1898. The accompanying map, Fig. 1, shows the complicated system of railways within the city limits, and shows also the lines elevated and depressed, or which are provided for by existing ordinances. It will be noted that several lines parallel each other, and have therefore to be dealt with simultaneously in the work of elevating the tracks. The various railways using the different passenger terminals in the city of Chicago are as follows, the numbers referring to the numbers marked on the map:

1. Wells St. Station:	C. & N. W. Ry.	
2. Union Station..	P., C., C. & St. L. Ry.	C., M. & St. P. Ry.
	P., Ft. W. & C. Ry.	C., B. & Q. Ry.
	C. & A. Alton R. R.	
3. Grand Central station.	C. T. T. Ry.	C. G. W. R. R.
	B. & O. R. R.	

4. Van Buren	C., R. I. & P. Ry. / L. S. & M. S. Ry.	N. Y., C. & St. L. R. R.
5. Polk St. Station	A., T. & S. F. Ry. / C., I. & L. Ry. / C. & W. I. R. R. / G. T. R. R.	C. & E. I. R. R. / Erie R. R. / Wabash R. R.
6. 12th St. Station	Ill. Cent. R. R. / Wis. Cent. R.R.	Mich. Cen. R. R. / C.,C.,C.& St L. Ry

We are indebted to Mr. John O'Neill, Superintendent of Track Elevation, for a copy of his annual report for the year 1899, which shows that the work of that year compared very favorably with that of other years. From this report we have prepared the following summary showing the work done and remaining to be done at the close of the year:

Track elevation and depression:	
Unfinished, Dec. 31, 1898	14.30 miles.
Required under ordinances of 1899	27.71 "
Required under all ordinances	77.21 "
Done in 1899	27.71 "
Done to Dec. 31, 1899	51.50 "
Yet to be done	25.71 "
Grade crossings eliminated:	
Balance on Dec. 31, 1898	88
Required under ordinances of 1899	96
Required under all ordinances	691
Eliminated in 1899	90
Eliminated to Dec. 31, 1899:	
By elevation, 379; by depression, 38	417
Yet to be eliminated	274
Subways: Built to Dec. 31, 1899	296
Yet to be built	274
Total provided for	570
Cost of work: Balance unfinished, Dec. 31, 1898	$4,230,000
Required under ordinances of 1899	6,133,000
Required under all ordinances	23,063,000
Expenditures in 1899	4,305,000
Expenditures to Dec 31, 1899	17,005,000
Yet to be expended	6,058,000

	Tracks—Elevated.	Tracks—Depressed.	Total.
Main tracks, miles	172.48	54.19	226.67
Other tracks, miles	83.88	4.09	87.97
Total tracks, miles	256.36	58.28	314.64
Subways built, No.	296	..	296
Grade crossings elim., No.	379	38	417

The figures in the above statement are, of course, exclusive of work planned but not yet definitely provided for. An important omission in this respect is the projected joint elevation of the tracks of the Atchison, Topeka & Santa Fe Ry., Chicago & Alton R. R., and Illinois Central R. R. (C., M. & N. R. R.), west of the Chicago River. This important piece of work is noted below, and is now the subject of negotiations between the railway officials and the city authorities.

As a matter of record in regard to individual pieces of work we give the accompanying list of ordinances passed up to Dec. 31, 1899, with the work covered by each one. This has been furnished us by Mr. O'Neill.

The reason why 178 subways are required to eliminate 132 grade crossings, under the ordinances of May 22 and Oct. 23, noted above, is that the railways which parallel one another in some cases require separate subways at the same crossing. Thus, where the A., T. & S. F. Ry., C. & A. R. R., and C., M. & N. R. R., are parallel with and adjacent to each other, from Stewart Ave. and 21st St. west to 200 ft. west of Ashland Ave., three subways are required at one street intersection, one for each railway. The P., Ft. W. & C. Ry. and the C. & W. I. R. R. are parallel with and adjacent to each other from 21st St. to 55th St., requiring two subways for each intersection. The total number of grades eliminated up to the end of 1899, being 417 in all, includes not only the grade crossings eliminated by subways, but also other street intersections that have been discontinued by the elevation of the roadbed and tracks of the various railways.

Atchison, Topeka & Santa Fe Ry.

As long ago as 1887-88, this railway elevated a portion of its Chicago Division, from a point near Robey St. to Kedzie Ave., a distance of 1¾ miles of double track. The average height of elevation was 14 ft., and four grade crossings were replaced by subways. The abutments are of first-class masonry, built of Bedford stone, and support plate girder bridges. The Kedzie Ave. subway has been put in during the present year. The total length of all tracks elevated is 3¾ miles, with five subways replacing five grade crossings. The A., T. & S. F. Ry. has also depressed its tracks at the 16th St. crossing, described below, so as to pass under those of the Lake Shore & Michigan Southern Ry., the Chicago, Rock Island & Pacific Ry., the St. Charles Air Line, and Clark St. The share of the total expense of this work which was contributed by the A., T. & S. F. Ry. was $164,770.

An ordinance passed May 22, 1899, requires the elevation of the tracks of the A., T. & S. F. Ry. and the Chicago, Madison & Northern R. R. from 18th St. west to the Illinois & Michigan Canal, a distance of 2.84 miles, with an aggregate length of single track of 12.23 miles. The same ordinance requires the elevation of the tracks of the Chicago & Alton R. R. from 18th St. west to South Albany Ave., a distance of 4.5 miles, with an aggregate length of single track of approximately 13.5 miles, also the elevation of the tracks of the Union Stock Yards & Transit Co., the Chicago Terminal Transfer R. R. Co., and the Pittsburg, Cincinnati, Chicago & St. Louis Ry., from the bridge over the Illinois & Michigan Canal east to the east line of Western Ave. Boulevard, a distance of 3,100 ft., with an approximate aggregate of 3.5 miles of single track. In all, this will make a total of 29.33 miles of single track. The maximum elevation above city datum to be 23.5 feet. The present viaduct over the tracks at 18th St. will be replaced by a subway.

The A., T. & S. F. Ry., the C., M. & N. R. R., and the C. & A. R. R. are required to construct jointly 17 subways. In addition to these, two are to be built by the A., T. & S. F. Ry. and C., M. & N. R. R.; 15 by the Chicago & Alton R. R., and 6 by the Pittsburg, Cincinnati, Chicago & St. Louis Ry., the Chicago Terminal Transfer R. R., and the Union Stock Yards & Transit Co. This will make a total of 40 subways. The masonry used may be of concrete, stone or brick.

Chicago & Alton R. R.

The only work yet done by this company is the elevation of about 800 ft. of a sidetrack on Grove St., north of 18th St., where it connects with the network of elevated and depressed tracks at 16th and Clark Sts., which is referred to later on. The latest track elevation ordinance has not yet been accepted by this company, but the city has made several attempts to induce it to agree to elevate its line from 18th St. southwest to Albany Ave., where the line strikes the Illinois & Michigan canal. The company objected to the work east of Halsted St., claiming that it would seriously injure its access to dock and elevator property on the Chicago River, and proposed that Halsted St. should be carried over the tracks by a viaduct, the eleva-

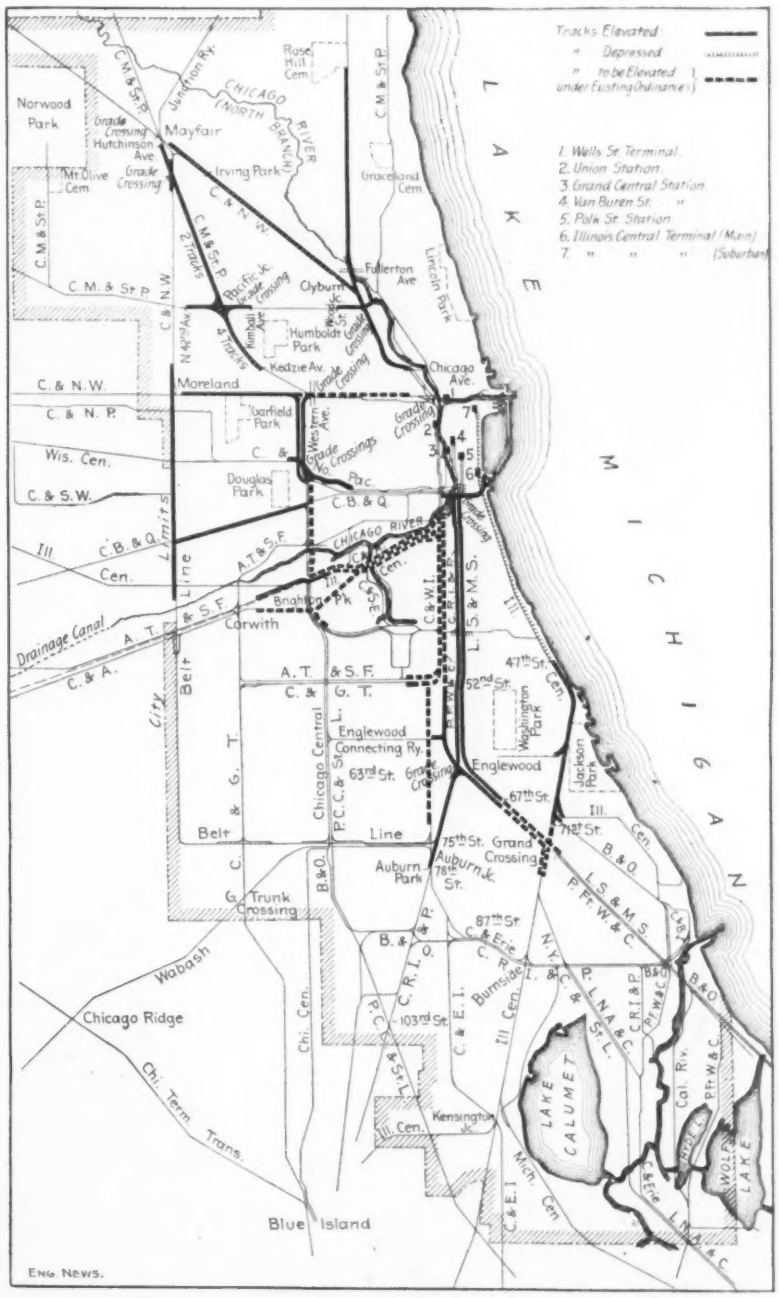

FIG. 1.—MAP OF CHICAGO RAILWAY TERMINAL SYSTEM, SHOWING LINES ELEVATED AND DEPRESSED.

crossed at right angles. Those 66 ft. or less in width have single span girders. Those over 66 ft. have rows of columns on the curb lines. The bridges were temporarily placed on piles at the full elevation, there being four piles at each end. For Lincoln Ave., requiring the whole 245 ft. of bridge to be erected at once, the material was loaded on cars, transported to the site, and placed upon the iron columns which had already been erected. The elevation at this crossing stopped street traffic for 20 days.

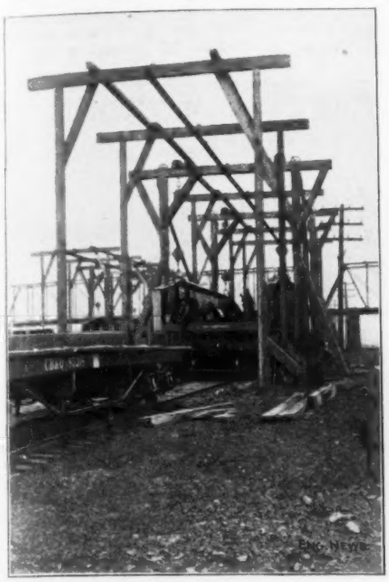

Fig. 4.—Bridge Erection Yard; C., B. & Q. R. R.

Wisconsin Division.—In 1898, this division was elevated for a distance of 4.6 miles, from Wood St. northwest to 44th Ave. There were three tracks on an average and the length of single track elevated was 13.8 miles. There were 25 subways substituted for as many grade crossings. The average height of elevation was 10 ft. Work was commenced March 24 and completed June 4, 1898. Bridges for 77 tracks were placed in 58 days, or an average of 1.3 tracks per day. The unloading of sand for filling was the item which regulated progress, and the record here was 5,800 cu. yds. per day for 58 working days; 98,000 cu. yds. of street excavation for the subways were also used in filling during this time, at a cost of 27 cts. per cu. yd., including overhaul. The work progressed at the rate of two miles of three-track railway, elevated 10 ft., per month. The traffic on this division was 55 trains per day.

After the completion of this work, preparations were made for extending the elevation from Diversey Boulevard (on the Milwaukee Division) and Wood St. (on the Wisconsin Division) southward to Chicago Ave. The distance was three miles, with three tracks for one mile and 7 for two miles, the length of single main track being 17 miles. The average height of elevation was 10 ft., and 23 subways were substituted for as many grade crossings. Work on the walls and foundations was carried on from July 6 to October, 1898, and the rest of the work was completed by July 1, 1899.

This piece of work included the elevating of the double track drawbridge over the north branch of the Chicago River at Deering for a height of 11 ft. 3 ins. This was done as follows: The approach girders were put in place for one track at half the elevation, that is about 5 ft. 7 ins., and single track was used over the bridge, the other track being graded up to this half lift previous to Saturday, May 19. At 8 p. m. on that day traffic was stopped, the bridge was opened, and scows filled and emptied of water used to lift it. While one crew were doing this, steam wrecking cars were used on each end to pull up the old rest piers. New piles were driven for the new rest pier and capped. A circular plate girder was then put on the stone pier 5 ft. 7 ins. high. All work was finished at 8 p. m. Sunday, May 20, and traffic resumed at half the elevation single track. During the following week the approach girders were put in place for the other track at full height, and the track was lifted to its final grade. This included the placing of bridges at Fullerton and Webster Aves., the first streets north and south of the bridge, for one track. Then on Saturday, May 27, at 8 p. m., traffic was stopped and the bridge was lifted by the use of scows and jacks, and short trestle bents were placed on the rest piers constructed the week before. A second circular plate girder was then placed under the one placed the previous week. The work of lifting was finished at 7 a. m. May 28. During May 28, the C., M. & St. P. Ry. crossing girders were lifted 5 ft. 7 ins. and moved 8 ft. in line of track. At 8 p. m. Sunday, traffic was resumed at the full elevation of 11 ft. 3 ins. over Fullerton Ave., the C., M. & St. P. Ry. crossing, the drawbidge (including approach girders of 31 and 51-ft. span) and over Webster Ave. This work was carried out under the supervision of Mr. J. W. Schaub, M. Am. Soc. C. E., and the contractors were Lydon & Drews, of Chicago. The circular girders placed on the center pier were assembled on a scow beside the pier, and when the bridge was lifted they were hauled into position in 30 minutes, this work being done by the Lassig Bridge & Iron Works. Fig. 2 shows a diagram of the drawbridge elevation.

There is also a short piece of elevation at Mayfair, made necessary by the elevation of the Chicago, Milwaukee & St. Paul Ry. over Milwaukee Ave. and Irving Park Boulevard.

Rockwell St. Line.—In 1897, the C. & N. W. Ry. elevated this section, including its own three tracks and the two parallel tracks of the Pittsburg, Cincinnati, Chicago & St. Louis Ry. The work extends from Fulton St. south to 12th St., a distance of 1.7 miles, with 10 miles of single track, there being an average of five to six tracks. The average amount of elevation was 10 ft., and 19 subways were substituted for as many grade crossings. The work was commenced June 1, and completed Aug. 24, 1897. As the bridges were only about 350 ft. apart, the work was done in sections of such lengths as to include four streets, and one street was made passable for teams by laying a plank roadway as soon as it was excavated to the new grade. The traffic aggregated 195 trains, or 3,170 cars, per day, except that at the 12th St. crossing it amounted to 316 trains, or 4,340 cars, per day. The work on this line was described in our issue of Oct. 28, 1897.

This road has now five track crossings at grade, three of which are on the elevated portions of the line: (1) Mayfair, (2) Clybourne Junction, (3) Canal and Kinzie Sts., (4) Western Ave. and Kinzie St. (all these are crossings of the C., M. & St. P. Ry.), (5) 12th and Rockwell Sts. (C. & N. P. Ry.).

The following table gives a summary of the work done by the Chicago & Northwestern Ry.:

Length of road elevated	14.85 miles
Length of single track elevated	60.00 "
Bridges (15,378 ft. of double track)	21,457 tons.
Abutments and foundations	77,900 cu. yds.
Retaining walls and foundations	63,460 " "
Gravel ballast	220,000 " "
Sand filling	1,495,000 " "
Street excavation	361,000 " "
Street paving	150,800 sq. yds.
Sidewalk paving	76,000 " "
Maximum height of elevation	10 ft.
Width of roadbed	66 to 100 "
Subways built:	
Highway, 90; footway, 5; railway 1; total	96
Street grade-crossings eliminated	150
Drawbridges raised	1

The cost of the work, as taken from the company's reports, has amounted to $2,928,742, of which $88,670 was the company's share of the cost of the work on the St. Charles Air Line (see Illinois Central R. R.). The average cost of work on the several divisions of the C. & N. W. Ry. has been as follows:

Divisions.	Cost	Per mile	
	Total.	Road.	Track §
Galena Division	$382,081	$212,267	$42,454
Milwaukee Division*	1,346,100	199,422	47,650
Wisconsin Division†	721,157	156,773	52,255
Rockwell line, Fulton-12th St.	390,723	229,837	39,072
Total	$2,840,070	$189,903	$47,335

*Milwaukee Div.: Chicago Ave. to Wrightwood Ave., $810,251; Wrightwood Ave. to Montrose Ave., $330,688; Montrose Ave. to Bryn Mawr Ave., $205,170; total, $1,346,100.
†Wisconsin Div.: Clybourne Junction (Armitage Ave.) to Mayfair.
§Single track.

An ordinance is now being prepared for the elevation of the tracks of the C. & N. W. Ry., and the P., C., C. & St. L. Ry., in Kinzie St., westward from Grand Ave. This will involve the removal of the viaducts over the tracks at Ashland Ave. and Western Ave.

Chicago & Western Indiana R. R.

This road has depressed its tracks at the Sixteenth St. crossing (noted farther on), and an ordinance has been passed by the track elevation committee of the city council providing for the elevation of its tracks from 19th St. south to 70th St. As far as 50th St. the tracks are alongside those of the P., Ft. W. & C. Ry., which will be elevated under the same ordinance. The C. & W. I. R. R. has a very heavy traffic, being the terminal for a number of other railways. It has also been suggested that the tracks should be elevated from the Polk St. terminal station southward until it is necessary to run down to the depressed tracks at the 16th St. crossing. This, however, would involve a somewhat heavy grade,

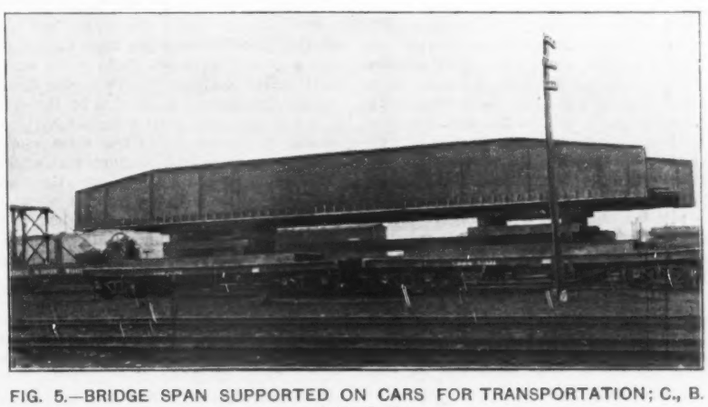

FIG. 5.—BRIDGE SPAN SUPPORTED ON CARS FOR TRANSPORTATION; C., B. & Q. R. R.

and the elevation of 12th St. viaduct, and if the tracks on this part of the line are to be eventually removed from the street level it seems more likely that this will be done by continuing the depression northward from 16th St. to the terminal. No steps have yet been taken as to this terminal work, and it is very far in the future.

Along W. 46th St., near the city limits, this road has about a mile of elevated track, extending from Jackson St. to Chicago Ave. This was built at an elevation, however, when the road was first constructed, and was originally carried by a single

tion then to begin west of that street. The city, however, is not desirous of building new viaducts and is very anxious to have the Halsted St. grade crossing abolished. The tracks of the Atchison, Topeka & Santa Fe Ry. and the Chicago, Madison & Northern Ry. (Illinois Central system), parallel those of the Chicago & Alton R. R. over much of the route which has been so long in dispute. The two former roads were understood to be willing to undertake their share of the work, but the refusal of the latter blocked the entire scheme, as the work must be done jointly. On May 22, 1899, an ordinance was passed by the city covering this work, and including the tracks of these three railways and also of the Pittsburg, Cincinnati, Chicago & St. Louis Ry., the Union Stock Yards & Transit Co., and the Chicago Terminal Transfer R. R. This has already been referred to in the description of the work of the A., T. & S. F. Ry. It is probable that this ordinance will be accepted by the Chicago & Alton R. R., under its reorganized administration, conditionally upon some modifications being introduced, including the termination of the elevation at California Ave., instead of Albany Ave.

Chicago & Northwestern Ry.

The Chicago terminal system of this road comprises 36.75 miles of double running track and 159.70 miles of yard track. The estimated cost of elevating this to comply with the terms of the O'Neill ordinance was about $65,000,000, this including the raising of the entire terminal 16 ft. The elevation was therefore strongly opposed by the railway company, until the city agreed to compromise by preparing ordinances covering only a part of the work at a time, thus allowing the work to be done gradually.

This company has been the most liberal in accepting the ordinances, and the most vigorous in pushing the construction. Its work is now all finished, as far as existing ordinances require. The terminal and the lines extending therefrom to Chicago Ave. and Western Ave. may perhaps be elevated later, but at present such work is blocked by the viaducts crossing the tracks. In regard to the alternative plans of street viaducts or elevated tracks, it may be noted that the extension of this company's track elevation further into the city is blocked by existing viaducts, as follows: the Galena Division by the Western Ave. viaduct; the Milwaukee and Wisconsin divisions by the Chicago Ave. viaduct; and the Rockwell St. line by the Ogden Ave. viaduct. The methods of carrying out the work, and the style of bridge used, were described and illustrated in our issue of Aug. 20, 1896.

The retaining walls are of rubble masonry, and the abutments of dimension stone. The masonry and bridge work were done by contract. The stone came from the company's own quarries, and all the steel work was done by the Lassig Bridge & Iron Works, of Chicago. The filling in, and all track work were done by the railway company. Two tracks were first elevated and piles driven in bents at each end to carry the plate girder bridges, except that where columns were to be placed on the curb line these columns were first erected and the bridges were permanently supported on them at once. The girders and floor for a single track bridge were assembled near the end of the work, and taken to the site on specially trussed cars. They were then landed on the supports by means of jacks.

Temporary incline approaches were then built and work trains were run, carrying sand for filling in between the bridges. The masonry abutments were afterwards built and the intermediate floors put in between the girders. The cost of the entire temporary work of piling, placing bridges, building back walls to hold the filling, and laying track stringers where foundations preceded the work of elevation, is estimated at less than $1 per lin. ft. of track, while the cost of temporary pile or trestle bridging is estimated at $5 per ft.

It will be seen from the figures given below that while the work has been spread over some four years, yet the actual time occupied has been but a few months of each year. The time has averaged about 45 days per mile of road on the Galena Division, 17.85 days per mile on the Milwaukee Division, 15.6 days on the Wisconsin division, and 5.14 days on the Rockwell St. line. The subways averaged 5.3 per mile, except on the latter line, where they numbered 13 per mile (Eng. News, Oct. 28, 1897). The work was planned and executed under the direction of Mr. L. H. Evans, Engineer of Track Elevation.

Galena Division.—On this division the track has been elevated for a length of 1.8 miles, with 9 miles of main track, and yards at each end. The

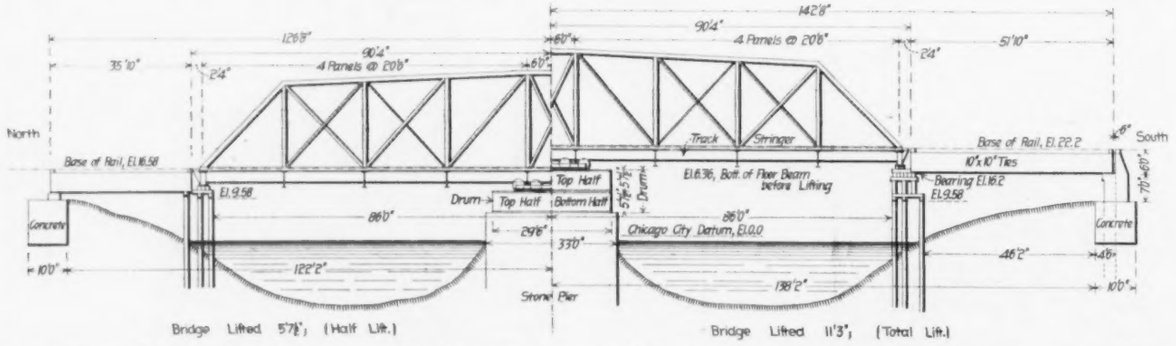

FIG. 2.—DIAGRAM OF THE RAISING OF THE C., & N. W. RY. DRAWBRIDGE OVER THE NORTH BRANCH OF THE CHICAGO RIVER.

The solid floor system of the bridges consists of floor beams 5 ft. c. to c., each composed of two 10-in. channels set back to back. Brackets or shelf angles riveted to the webs of the channels support track stringers, consisting of two Z-bars, 3½×6 ins., and a bottom plate ¾×10 ins. This forms a trough whose top is level with the top of the floor beams. In each trough is an oak stringer about 6×16 ins. to 7×16 ins., the difference in thickness being to allow for a transverse camber of 1 in. in the floor for drainage. The stringers are aout 4 ft. 6 ins. long, and tar filling is poured between them and the sides of the trough, and between their ends and the webs of

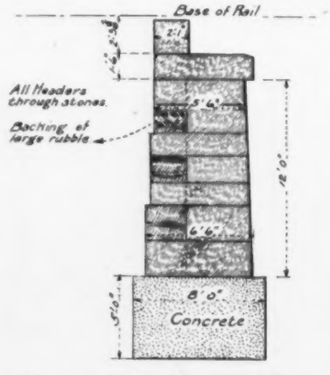

Fig. 3.—Masonry Abutment on Track Elevation Work; Chicago, Burlington & Quincy R. R.

the floor beams. The 80-lb. and 90-lb. track rails rest on flat tie-plates on these timbers, and were at first secured by bolted clamps, the bolts passing through the bottom plate, from which they were insulated by short sleeves. In this year's work, however, the rails are spiked to oak blocks. Two angle irons, 3½×5 ins., are riveted to the top flanges of the trough Z-bars, having the 5-in. leg vertical and the 3½-in. leg turned inward. These form the guard rails. The floor is covered with 5-16-in. plates, riveted between the guard rails and troughs, and stiffened by angle irons on the under side. Gusset plates are riveted between the floor beam channels and to the stiffeners of the plate girders. The weight of the floor, exclusive of gussets and guard rails, is about 530 lbs. per lin. ft. of bridge.

average number of tracks for this distance was five, and the average height of elevation was 10 ft. Seven grade crossings have been replaced by subways, the first of which is at Sacramento Ave. and the last at 40th St. Work on this division was commenced on April 15, 1895, and completed July 10, 1895, traffic being interfered with for only 55 days. The traffic averaged 294 trains with 2,619 cars per day.

Milwaukee Division.—The successful execution of the first piece of work above described, its cost and the rapidity with which it was carried out, encouraged the company to consider the extension of the system. In 1896 it accepted an ordinance for the elevation of portions of the Milwaukee Division and Wisconsin Division, and the work was done in 1897, although the ordinance allowed eight years. The elevation of the Milwaukee Division extends from Diversey Boulevard north to Balmoral Ave., a distance of 3.75 miles, with an average of three tracks, the total length of single track elevated being 11.25 miles. The average height of elevation was 8 ft. There were 21 subways, replacing as many grade crossings. Work was commenced at Berteau Ave., June 16, 1896, and completed for the season at Diversey Ave., on Aug. 7, 1896. It was resumed on April 12, 1897, and completed to Balmoral Ave., Rosehill, on May 12, 1897. Some of the traffic was diverted, but 76 passenger trains passed over the line daily.

Two tracks were in use and a third track was laid; the two tracks were lined over about 6 ft. as the work progressed, and the third track was laid just ahead of the elevation. Single track was maintained through the section being elevated; that is to say, about half a mile of single track was necessary, with switches at each end, in the double track, at the north end, where it had been elevated, and into the double track at the south end just ahead of the elevation. These switches were removed as the elevation progressed. Train dispatchers were at each end of the single track and prevented any delay to trains in passing over this single track section, except that the rate of speed was reduced to about ten miles an hour, making a delay to trains of not more than five minutes. About 3,000 cu. yds. of material were handled per day and the work advanced at the rate of 200 lin. ft. per day, necessitating the placing of a bridge every second day. This was done with regularity.

All the streets, except Lincoln Ave., were

of 300,000 cu. ft. of water per minute can be passed through this channel toward the Mississippi.

Chicago has done all this, and with this magnificent achievement added to the many which she has wrought before, what we now hope for is that this great government of ours will take hold where Chicago has left off and complete her enterprise, and that her ships and boats shall pass from Chicago to the Gulf and beyond through this channel, which we hope will be within the near future.

The story of the canal has been told too often for me to dwell upon it here, but I cannot drop the theme without speaking of those who have gone before, and those who have held up my hands in this mighty work. Those who preceded me planned wisely and well. There has been but little that I could change or better, and in the mighty work I have had the strong hands and fertile minds of many faithful helpmates. Without this loyalty I could have accomplished nothing, and I wish to make a record of it here. Within a very few days I hope you will mark a noted change in the condition of the Chicago River. That stream which has smelled to heaven for so many years is about to be cleansed and pure waters flow where vile streams have festered for so long.

BUILDINGS FOR THE PAN-AMERICAN EXPOSITION OF 1901, BUFFALO, N. Y.

The Board of Architects appointed by the management of the Pan-American Exposition, to be held at Buffalo, N. Y., in the summer of 1901, is made up of eight well-known architects—three resident in New York, two in Boston and three in the city of Buffalo. This board has adopted plans for the following buildings: Mr. Walter Cook, President of the New York Chapter of the American Institute of Architects, and of the firm of Babb, Cook & Willard, New York, has designed the Stadium, or screen in front of the railway station, and the entrance to the Midway. Mr. R. S. Peabody, of the firm of Peabody & Stearns, of Boston, is the architect for the three buildings for Horticulture, Graphic Arts and Forestry, and Mr. Edward P. Green, of Green & Wicks, of Buffalo, has designed the Machinery and Transportation Building, which is here illustrated from the architect's perspective sketch.

PERSPECTIVE VIEW OF THE TRANSPORTATION BUILDING FOR THE PAN-AMERICAN EXPOSITION OF 1901.
Green & Wickes, Architects, Buffalo, N. Y.

The Plaza, bounded by the first-named structures, will form a square about 500 by 350 ft., with buildings on three sides. The central part of this square will be occupied by a slightly raised terrace, surrounding a sunken garden, in the middle of which will be the band-stand. North of the Plaza is the railway station, which will be masked by a colonnade flanked at either end by two colossal arches, one for the entrance and the other for the exit of visitors. This colonnade will be surmounted by a trellis which will be covered with vines of various kinds. The west side of the Plaza is bounded by a building of Spanish design, two stories high and about 350 ft. long, which will serve as a restaurant; and through the lower arches of this building visitors will pass to the part of the Exposition called Vanity Fair, corresponding to the Midway Plaisance at the Chicago Exposition. On the east of the Plaza will be a building, closely resembling the restaurant, which will serve as an entrance to the Stadium, or athletic field. This building will be two stories high, and portions of it will be used for exhibition purposes. On the south side of the Plaza will be the electrical tower now being designed by Mr. Howard.

The plans for the Stadium have been carefully worked out in all their details, and it will generally resemble the structure erected at Athens a few years ago for athletic contests. It will easily contain 25,000 spectators; it has a quarter-mile running track, with a space inside for games; and the Stadium will also be used for certain pageants, motor vehicle exhibits, and those of horses, live stock, agricultural and road machinery, etc. Including the building forming the entrance, the Stadium will be 870 ft. long by about 500 ft. wide.

The three buildings for Horticulture, Graphic Arts and Forestry will form a picturesque group at the end of the West Garden. The first-named will be the largest and will occupy the central position, with arcades connecting the buildings, and the whole so arranged as to form a semicircular court in front. The Horticultural building will cover 45,000 sq. ft.; while the other two, similar in design to each other, will cover 30,000 sq. ft. each. The central building is square in plan, with a lantern rising to a height of 240 ft.; the two side buildings will each have four corner towers and a vaulted loggia of three arches, forming the entrances. Red roofs of Spanish tile will surmount all these buildings; and the broad white wall surfaces of the center building will be decorated with colored bas-reliefs, twining vines, etc., while the decoration of the side buildings will be chiefly confined to the vaulted ceilings of the loggias.

The Machinery and Transportation building will form a hollow square, with arcades on all sides and an interior court 100 by 200 ft. In this court will be a pool and a fountain. The roofs will be red tile, the walls cement, with a color scheme of light reds and yellows. The openings will be grilled with wrought-iron screens, designed after Spanish "rejas" of the 16th century. Vines and flowers will be abundantly used so as to blend with the coloring of the buildings.

FACING POINTS AND SLIP SWITCHES.*

By A. H. Rudd.†

In his paper presented at the November meeting of the club, in Boston, Mr. Sperry says:

For facing switches in main lines an improvement in facing point locks is still to be desired, so as to make it impossible to lock a switch in the wrong position. Some effort has been made in this direction in Great Britain, but it is the exception in this country. Some of our more progressive lines are now specifying bolt locks on all facing main line switches, whether they be operated by switch and lock movement or locked by facing point locks. This is a step in the right direction, as a bolt operated by the signal connection is a most efficient check on the proper operation of the switch.

The writer called the club's attention some time ago to the lock movement invented by Jas. H. Baylett, which covered this point, but required the switch to be thrown after each unlock, in order that it might be locked a second time, which was certainly a disadvantage, though the device was even then an improvement on the plain facing point lock.

The general opinion appears to be that bolt locking is the best possible solution at the present time, the idea of accomplishing the work by the locking arrangement alone not being perfected or sufficient. Where switches lie between tower and signal this may be accomplished without much complication, but if beyond the tower the wires must have extra turns, and the disadvantages of hard pulling levers, and other well-known troubles almost equal the advantages gained. As the writer understood this practice, not all signals, but only those governing high speed routes, have bolt locks, and of course dwarf signals governing over switches in both positions cannot be protected in this way. If such is the case he would suggest the following practice at all points where separate levers are employed for high speed routes, as his scheme would protect these only. After evolving it, it dawned upon him that it was simply an application in a certain way of the idea embodied in the back indication device of the pneumatic machine, and he is not prepared to say whether it conflicts with patents covering this device. Light may be thrown upon this feature by some of our Union Switch & Signal Co. members.

The scheme consists simply in attaching to each facing switch a circuit closer or switch instrument of any standard make in circuit with a gravity battery, and an electric lock on the tappet of the home lever governing the high speed route over this switch or switches, when these latter are set for this route the circuit is closed and lock plunger withdrawn. If any swich, however, is set for a diverging route the circuit is broken and high speed signal locked.

This is a very practicable arrangement, as great leeway may be allowed in adjustment of the closer. The facing point lock will take care of the switch, if it does not face properly, the function of the electric lock being simply to insure that the switch does not remain without any movement in the diverting position. If it moves only ½-in. from this reversed position, the facing point lock will not operate, consequently a sliding contact can close the circuit during any part of at least 3½ ins. of the switch movement with perfect safety.

With bolt locks and adjusting screws in the towers (where they should be placed to prevent tampering with them), there is a possibility of the repairman carelessly shortening the front wire to such an extent that the bolt will not clear the lock rod with the signal at danger, and the switch be tied up. With the suggested arrangement wire runs can be kept straight, and high, and level, and the danger of their freezing up at the bolt lock obviated.

The local conditions must determine the difference in initial cost, but the following may be taken as a basis: Bolt locks on concrete foundation in place, $6. Circuit closer in place on tie, $6. (It is believed that a simpler and still cheaper closer can be furnished for this work.) Electric lock in place $12 to $15. Run of signal or insulated wire to be determined by the location of switches, and consideration given to the saving of trouble likely to occur on bolt locks, and to the fact that battery must be maintained.

Slip Switches.—The usual method of connecting double slip switches is to join the four points at each end rigidly, operating one end, and the far end of the next set together as a crossover (as in Fig. 1) or one end and its movable point frog on one lever, either of which methods is perhaps an overload. At points when main lines cross, as in Fig. 1, and the straight routes AA, BB, CC, are most

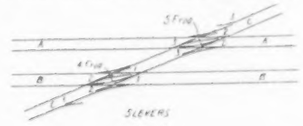

Fig. 1

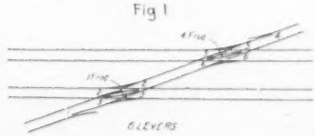

Fig. 2

frequently used, the manipulation, to change from AA to CC, for instance, is considerable, particularly when two levers are used for the locks on each set of slips, and the trailing points are locked. In such cases it is probably preferable to connect and number as shown in Fig. 2, especially where the roads are double or four tracked. This plan is certainly worth considering carefully.

THE MARINE LIFE-SAVING COMPETITION, for which the heirs of Anthony Pollock, of Washington, D.C., offer a $25,000 prize, will be open to the world, and printed rules of the international jury have been issued. The American member of this jury is Lieut. Wm. S. Sims, U.S. Naval Attache at Paris. The award will not be made until after the close of the Paris Exposition, and must then be approved by Commissioner-General Peck, for the United States, and Alfred Picard, the Commissioner General of the Paris Exposition.

*Abstract of a paper presented at the meeting of the Railway Signaling Club, in Chicago, Jan. 9.
†Signal Engineer; N. Y., N. H. & H. R. R.

track trestle. During the present year the trestle has been filled and replaced by an embankment wide enough for two tracks, with plate-girder bridges over all streets. This work has been done under the direction of Mr. E. H. Lee, Engineer and General Roadmaster.

Chicago, Burlington & Quincy R. R.

During 1898-99 this road carried out the elevation of its main line from the P., C., C. & St. L. Ry. crossing at Campbell Ave. to the Belt Line (C. & W. I. R. R.) at South 46th Ave., a distance of 2¾ miles. The Belt Line is already elevated, and the road has therefore to pass under it, but as 46th Ave. is on the city limit, there is no reason for elevating the C., B & Q. R. R. tracks west of it.

In Fig. 6, at Albany Ave., one span has been erected on the framed bents, while the elevation of the adjacent track on blocking (across the street) and sand filling has been commenced. On the side of the girder will be noted the angle brackets or knees for the attachment of the beams of the intermediate floor. Fig. 7 shows the Washtenaw Ave. subway, with the tracks elevated, a span in place for the third track, and the fourth (working) track partly elevated by blocking and filling.

The work thus far done is all west of Western Ave., and is not yet completed. Mr. T. S. Howland, Secretary of the C., B. & Q. R. R., informs us that up to Aug. 31, 1899, the cost had amounted

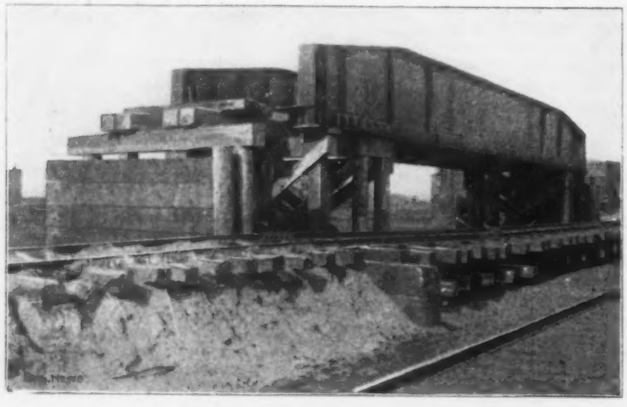

FIG. 6.—TRACK ELEVATION WORK IN PROGRESS; C., B. & Q. R. R.

FIG 7.—TRACK ELEVATION WORK AT WASHTENAW AVE. SUBWAY; C., B. & Q. R. R.

There are four main tracks and numerous sidings into factories, etc., the length of single main track elevated being 11 miles, and total length of all track elevated, 12¼ miles. The average height of elevation is 10 ft., and 16 subways will replace 14 grade crossings, the streets being depressed 2 ft. to 4 ft. The retaining walls are of rubble limestone, while the abutments are of Romona (Ind.) limestone at 12 subways, Illinois limestone and Cleveland (O.) sandstone at three subways, and sandstone at the other subway. All the work was done by day labor, and the plate girder bridges were built by the Lassig Bridge & Iron Works, of Chicago. There are no track crossings at grade on the elevated line.

As this work is on the main line, special care had to be taken to prevent interference with the traffic, and two tracks were kept open all the time. This plan worked very well. Little trouble has been experienced with sewers, but large sewers have been strengthened by T-rails and concrete roofs. The abutments have concrete foundations 8 ft. wide and 5 ft. thick, and the masonry courses vary from 24 to 30 ins. in thickness. Fig. 3 shows a typical cross section of the abutments. The stones were laid by means of a locomotive crane with a long boom, the capacity being 25 tons at a radius of 16 ft. (the crane being steadied by outriggers), or 6 tons at 38 ft. radius, without outriggers. The foundations and lower courses of the masonry were executed in 1898, and the work of elevating the track and putting in the girders was done in the spring of 1899, the method adopted being similar to that employed on the Chicago & Northwestern Ry.

The bridge floors consist of 12-in. I-beams, 14 11-32 ins. c. to c., resting on the bottom chords of the girders and covered with 5-16-in. deck plates. A ½-in. plate 20 ins. wide is laid under each rail, and along each edge is an angle iron ½ × 3½ × 5 ins., with the 5-in. leg vertical and the 3½-in. leg turned inward. These form the guard rails, and are backed by smaller angle irons riveted to the 5-16-in. deck. The rails rest on strips of vulcanized fiber for insulation and are secured by bolted clamps, the bolts passing through the ½-in. plates. The plate girders are 13 ft., c. to c. Fig. 4 shows the bridge erection yard, with one of the single track spans being loaded upon the flat cars for transportation, and Fig. 5 shows the way in which the spans were supported on the cars.

to $423,848, or $154,127 per mile, or $38,532 per mile of single track. In addition to this, the company had paid $103,885 (including land and tracks) toward the elevation of the St. Charles Air Line, making a total expenditure of $527,733 in connection with the Chicago track elevation work. The style of construction adopted was planned by Mr. E. J. Blake, Consulting Engineer, formerly Chief Engineer, and carried out by Mr. W. L. Breckenridge, Chief Engineer. The execution of the work has been under the direction of Mr. George H. Bremner, Assistant Engineer.

OPENING OF THE CHICAGO DRAINAGE CANAL.

After many delays the water has been at last let into the Chicago Drainage Canal, and a definite step has thus been made in the long continued controversy between the Drainage Board and the special commission appointed by Governor Tanner to see if the work done complies with the requirements of the law. The two sides to this controversy were presented at considerable length in our issue of Dec. 7, 1899. During the last week of the year, a large dredge was at work completing the "collateral channel," described in the above article, which channel is parallel with Kedzie Ave., and runs from the South Branch of the Chicago River towards the canal. A timber sluiceway with gates was fitted in the canal end of this channel, with a timber flume from the sluice gates to the canal, the end of the flume being turned eastward, or up-stream, so as to prevent the rush of water from washing the opposite bank of the canal. A ridge of earth was left unexcavated between the channel and the sluiceway, and it was understood that this would not be cut through or the gates opened until the official permission had been granted by the Special Commission.

On the morning of Jan. 2, however, the trustees of the Drainage Board, with the Chief Engineer, Mr. Isham Randolph, met at this place, and the dredge was put at work. A few minutes after 11 a. m. the ridge was cut through, the gates were removed, and the water of the river was admitted to the canal. There was no ceremony, but the step was taken quietly and with some secrecy, in order to prevent the work from being stopped by an injunction. The flow of water is only about side of the basin, are provided to control the flow 50,000 cu. ft. per minute, at which rate it will take from 8 to 10 days to fill the canal to the level of the sill of the locks at Lockport.

The canal is 28 miles long, from the Chicago River (at Robey St.) to the controlling works at Lockport. The distance from Lake Michigan to Robey St. is 6 miles, and below Lockport is the tail-race, 6,500 ft. long, which carries the water to the Des Plaines River. The total distance from the mouth of the river to Joliet is about 40 miles. The bottom width of the canal is 160 ft. in rock and 202 ft. in earth, although the earth excavation has been taken out to a width of only 110 ft. for the greater part, this being sufficient for the present flow of 300,000 cu. ft. of water per minute. The depth is about 36 ft., with a minimum depth of water of 22 ft. The canal extends from the Chicago River at Robey St., to Lockport, where it terminates in a broad basin for vessels to turn. Sluice gates and a bear-trap dam, at one side of the basin, are provided to control the flow of water from the canal into a tail race leading to the Desplaines River, the flow being then along the valleys of the Desplaines and Illinois River to the Mississippi. The main object of the canal is to reverse the flow of water in the Chicago River, which receives practically all the city's sewage, and thus prevent the sewage from polluting Lake Michigan, from which the city draws its water supply. It is also planned to make this part of a great waterway for large vessels extending from the Great Lakes to the Mississippi. The cost to date has been about $33,000,000. The bill for the canal was passed by the Illinois Legislature on May 29, 1889, and accepted by vote of the people Nov. 5, 1889. The actual work of construction was commenced Sept. 3, 1892. The work has been in charge of the following chief engineers:

Lyman E. Cooley, Feb. 1, 1890, to Dec. 10, 1890.

Wm. E. Worthen, Dec. 17, 1890, to April 21, 1891.

Samuel G. Artingstall, May 9, 1891, to Jan. 16, 1892.

Benezette Williams, Jan. 16, 1892, to June 7, 1893.

Isham Randolph, June 7, 1893, to date.

In this connection we give below the remarks made by Mr. Randolph at the annual banquet of the Western Society of Engineers, Jan. 2, which (as already noted) was the date on which water was turned into the canal:

The little barrier of earth which kept back the flow of Lake Michigan from that great ditch which we have dug was broken about 10 o'clock this morning (Jan. 2, 1900), and now the waters are running through the sluiceway from which the channel is to be filled. The sills of the gate at Lockport are 15 ft. above Chicago datum. The closed gates will hold the water up to the level of Lake Michigan, even though that level should reach 5 ft. above datum. This channel must be filled full to the brim before the work can be completed. At Campbell Ave. there is a dam across the channel made by dumping earth to protect the bridge work which has been in progress there for some time past; and that bridge work, for its magnitude and speed of completion, challenges comparison in the way of rapid substructure construction. It will take about eight days to fill the channel. After that the barriers which I mention will be removed and the full flow

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ADVERTISING RATES: 20 cents a line. Want notices, special rates, see page XXI. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.

Apropos of our discussion of the Trust problem in our issue of Dec. 14 last, we note with interest the recent address by President Arthur T. Hadley, of Yale University, at the Convocation of the University of Chicago. The following is an extract:

> Organization in business, in local politics and in national politics has brought with it an inequality of opportunity and an unfairness of conditions in which the game of life is played. Competitive business is giving place to trusts. The town meeting has been supplanted by the organized municipality. The old federation of states, with strong traditions of home rule, has become a centralized nation, reaching out beyond its old borders to rule over other nations less civilized than itself.
>
> Under these circumstances it becomes impossible for the community to rest complacently in that egotistic morality which seemed sufficient for the needs of a earlier generation. We can no longer rely upon competition to protect the consumers against abuse when industry has become so highly organized that all production is centralized in the control of a single body. It is no longer true, in the sense that it was 50 years ago, that each man may be left free to manage his own business, and that the community will find its work best done as a consequence of such freedom. Commerce and industry are no longer to be regarded as games where we have nothing to do but to applaud the most skilful player when he wins, and rest in the assurance that his triumph is in line with the best interests of the community as a whole.
>
> What was once regarded as a game has now become a trust, not merely in the superficial and accidental sense in which the name "trust" is now applied to all large combinations of capital, but in a profounder sense—as a trust exercised on behalf of the public, which it is in the power of those who control the capital to use well or ill at their pleasure, without adequate restraint from any quarter. Where competition is thus become a remote contingency, and where law is almost necessarily inadequate unless it be made so strict as to forbid the good no less than the evil in private business enterprise, a new system of ethics is a matter of vital necessity for the American people—a system which shall treat the director no longer as an individual pursuing private business of his own, and with the right to resent the suggestion that he should conduct it unselfishly, but as having moral responsibility to his stockholders, to his workingmen, and to the consumers that purchase his goods or his services. In the absence of such an ethical advance, no political or legal solution of the so-called trust problem is likely to be effective.

There have been few better things said or written respecting the question of monopoly than the above. The only point in which we would at all differ from President Hadley is as to the expediency of legislation to form and mold public opinion. He admits, in another part of his speech, which we do not reprint, that personal morality in American life is much in advance of political and commercial morality. Does it not follow, then, that what is most needed is to make the ethical standards which govern private conduct applicable to public affairs? The need, as President Hadley well says, is that Directors and other responsible officers of corporations should realize that they are in a large sense trustees—guardians not only of the interests of their stockholders, but of the interests of their employees, and of the public under whose franchise they operate. But will they realize this until the responsibility is made a legal as well as a moral one? Laws are indeed useless unless they are backed by public opinion; but at present public opinion is in advance of law, and is impotent to effectively express itself. The need is not for more laws, but for better ones. Not more restrictions upon corporate actions, but more effective guidance of such actions. Ethical standards of private conduct may be raised never so high, but directors of corporations will continue to conduct business in the future as in the past, until the law steps in and newly defines their duties and responsibilities. Corporations must obey the laws. They cannot safely do otherwise; but we shall wait long to see them recognize their obligations to the public to any greater extent than the law compels.

The public works of Chicago are admittedly in a bad condition, and this unfortunate state of affairs was alluded to very plainly by the Commissioner of Public Works in a recent address before the Western Society of Engineers, an abstract of which is given in another column. The city has spent enormous sums on public works, but the trail of politics smears nearly every item of work except, we believe, the construction of the drainage canal, and is evident in open frauds, in reckless waste and misappropriation of money, and in work of a seriously defective character. The columns of the Chicago papers for the past year alone would form material for an extensive article on this subject. We need only here refer to the bridges over the Chicago river as an example of these conditions. Several of these bridges are defective and even dangerous, and some of them have of necessity been closed to traffic. But the city has no funds available for repairs or reconstruction, notwithstanding the fact that the officials in charge of public works have plainly stated the serious condition of these structures to the higher authorities.

In the address above referred to Mr. McGann intimated that the Western Society of Engineers should help the city to solve some of its problems. We cannot see, however, that any good end would be secured by the Society entering upon such an undertaking except perhaps to the extent of taking some part in the campaign of public education. If the city wants advice on engineering matters, it should formally retain experts and not seek advice from a society whose membership necessarily includes men of all branches of the profession and of varying degrees of capability. It is true that experts would expect to be paid, but the paid advice of such men would be of far greater value than the gratuitous advice of a body of men which (as a body) is practically irresponsible. If a man is sick, he does not ask a medical society to discuss his disease and present him a report thereon, free of charge, but he employs a doctor or surgeon. The one man, or two or three in consultation, making a personal diagnosis and special study of the case can render much more effective aid than a whole body of casual investigators.

Whatever any engineering society, or for that matter, any professional society, can do to further good government, it ought to do, of course; but rendering gratuitous advice on professional matters is not the proper function of an engineering society.

A certain paint was recently advertised in a wholesale fashion as a remarkable discovery, and was guaranteed to stand uninjured tests which would destroy any of the standard paints on the market. Its merits were also attested by glowing "write-ups" in various trade journals, and testimonials from enthusiastic users. As the paint was stated to be a patented composition, we thought it worth while to secure a copy of the patent. Here is the composition of the paint as set forth by the inventor:

> The compound constituting my improved paint consists of the following ingredients: Coal-tar, 50 gallons; pitch, 25 lbs.; common mineral paint, 2½ lbs.; hydraulic cement, 5 lbs.; gray ocher, 2½ lbs.; asbestus (in powder form), 4 lbs.; air-slaked lime, 5 lbs.; dairy salt, 2 lbs.; liquid drier, ½-gallon; litharge, 1 lb. When the paint is to be applied to tin, paper, or iron, the lime may, if desired, be omitted; but when the paint is to be applied to brick, stone, wood, or similar porous material, I prefer to include the lime. Other ingredients—such as the drier or the pitch—may be omitted, if desired.
>
> I do not wish to be understood as restricting myself to the exact proportions herein stated, as such proportions may be varied to some extent without affecting the result to be accomplished.

Exactly what kind of a "dope" would result from compounding the above-mentioned materials would puzzle an expert chemist to tell; and the inventor wholly fails to state the philosophy on which he has selected his heterogeneous ingredients. As the proportion of coal tar to the other stuff is about 8 to 1, however, we strongly suspect that the mixture would have all the virtues of coal tar as a paint, and our readers can judge for themselves how far the "dairy salt," "ocher" and other ingredients would avail to neutralize its failings.

THE PROGRESS OF TRACK ELEVATION IN CHICAGO.

The railways entering Chicago have within the past few years had to encounter and solve a difficult problem at a very large expense. Practically all the lines were built at a time when the city was comparatively small, and when the wonderful growth of the city and of its railway traffic could hardly have been foreseen. Under these conditions, and in view of the perfectly flat character of the country, it was natural that the railways should be built upon the general surface of the country, cutting across the city lots and crossing the streets at grade. As the city grew and its trade increased, the railway traffic crossing the streets began to cause serious interruption to street traffic, and to be a source of numerous accidents. This state of affairs called for the passage of ordinances by the city council of a precautionary character; these included ordinances regulating the speed of trains; providing for gates and guards at all of the street intersections crossed by railway tracks; compelling the railway companies to fence their right of way; regulating the length of trains and the number of cars that should constitute a train; prohibiting the ringing of engine bells as the trains passed through the city; and compelling all trains to come to a stop on each side of a crossing where there was a street railway. All of these ordinances entailed more or less delay and expense upon the railway companies.

At the time when the grade crossing question became a serious problem, there were nearly 1,600 miles of railway tracks on the surface within the present limits of the city, owned by 28 trunk lines having their terminals situated near the main business center of the city and extending in all directions to the boundaries of the city, these lines crossing each other's tracks at various points. The tracks of these railways had grade crossings of the public highways and streets to the number of between 2,000 and 3,000. Over these tracks and in every direction through the city were moved daily about 19,000 freight cars drawn by about 1,000 freight locomotives, and about 4,420 passenger cars, drawn by about 765 passenger locomotives. More than 1,000,000 persons per day, upon an average, crossed one or the other of these railway tracks upon the highways and streets in vehicles and on foot, and more than 300 persons were killed by the railway cars every year, while many more were maimed or injured by the same means. Large amounts of property were destroyed at such grade crossings by the same cause, and the amount of expense and loss caused by delays to vehicles and pedestrians at these crossings was estimated to amount to several million dollars per year. The expense and loss to railway companies caused by delays made necessary in operating their railways at grade in the city, and by their liabilities for damage and injuries to per

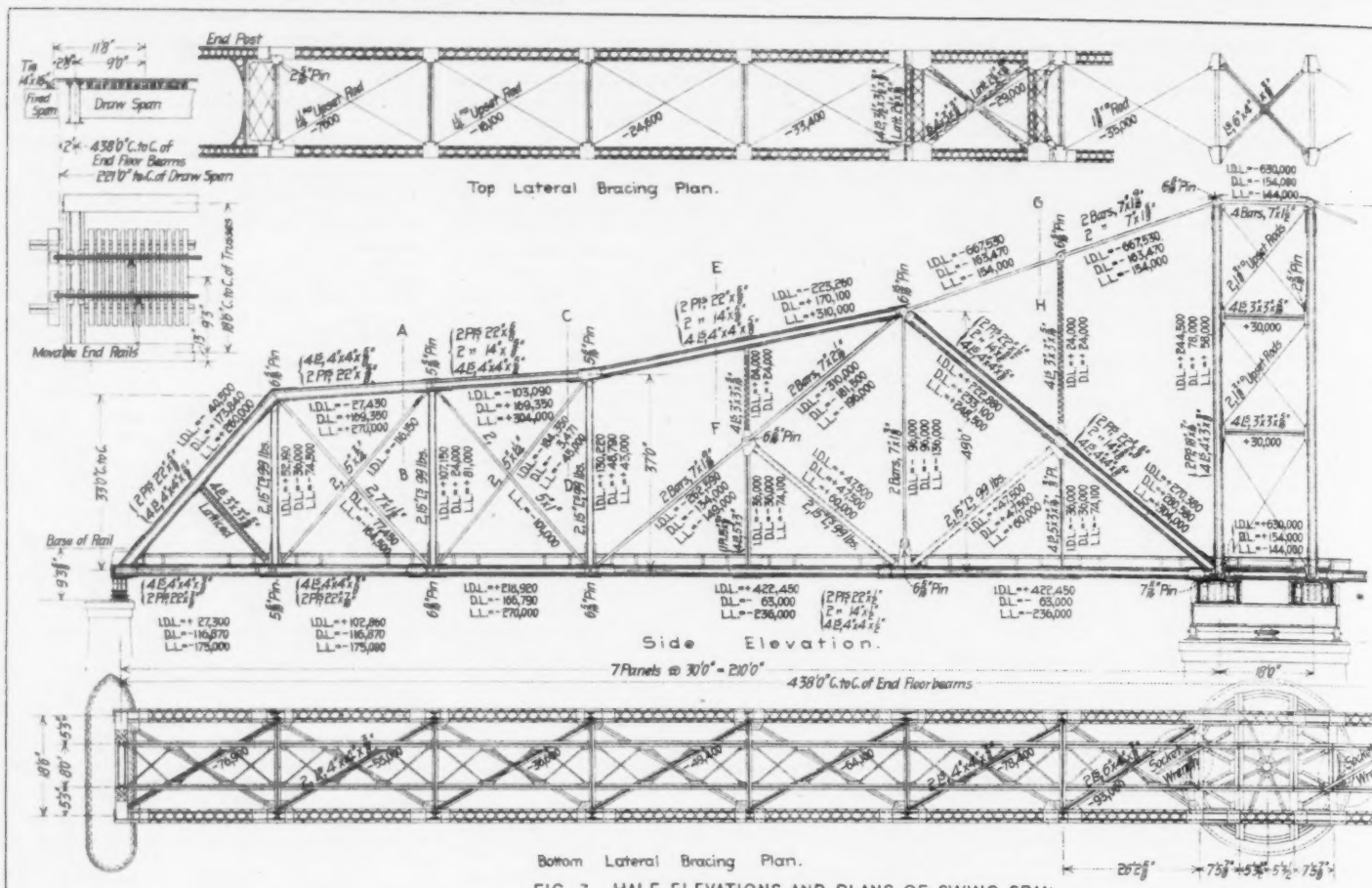

Top Lateral Bracing Plan.
Side Elevation.
7 Panels @ 30'0" = 210'0"
438'0" C. to C. of End Floor beams
Bottom Lateral Bracing Plan.
Cross Section at Center

FIG. 7. HALF ELEVATIONS AND PLANS OF SWING SPAN.

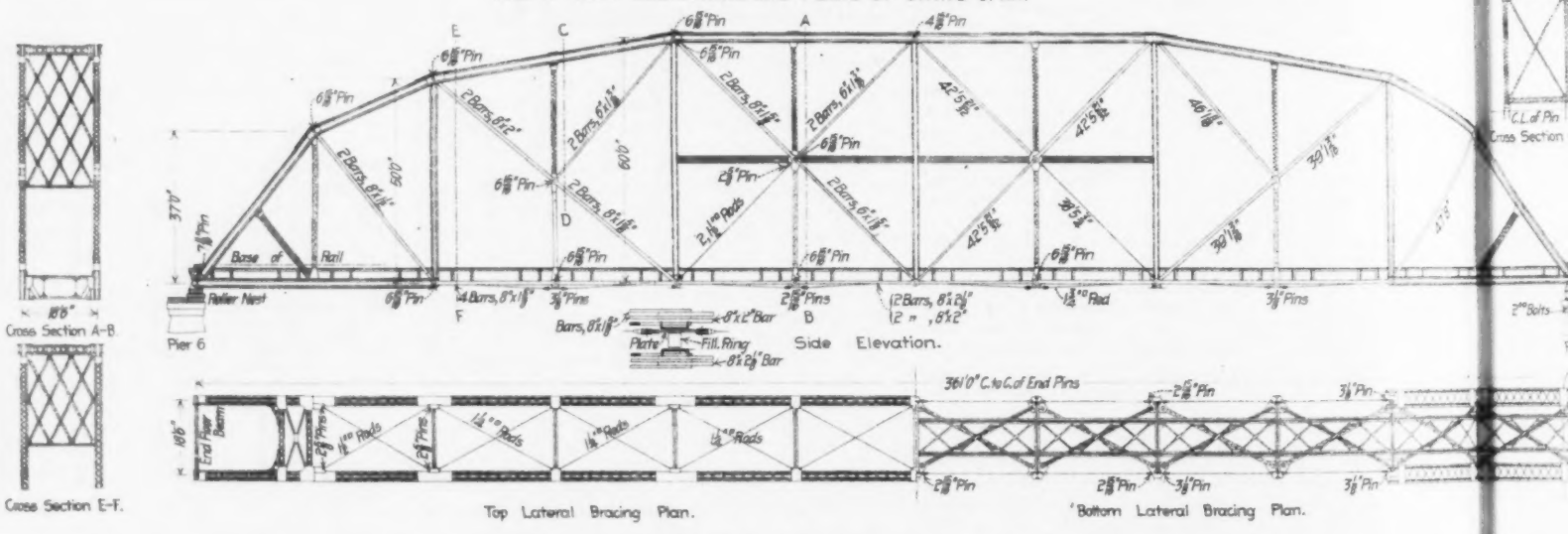


FIG. 5. HALF PLANS AND ELEVATIONS OF 361-FT. FIXED SPAN.

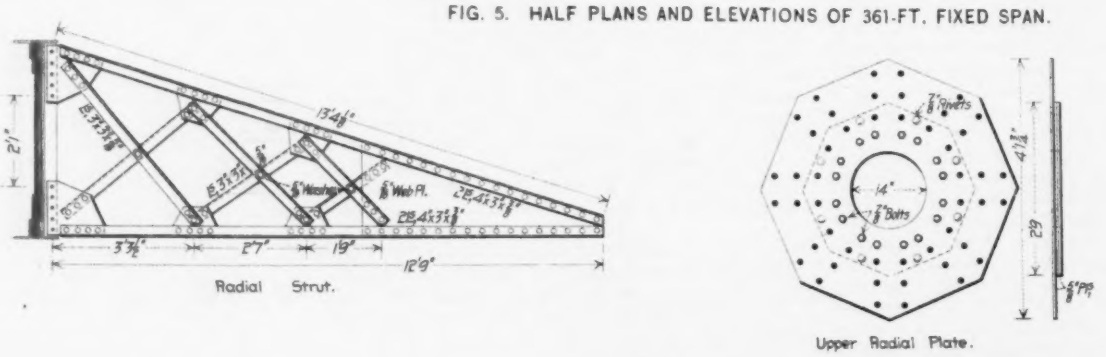
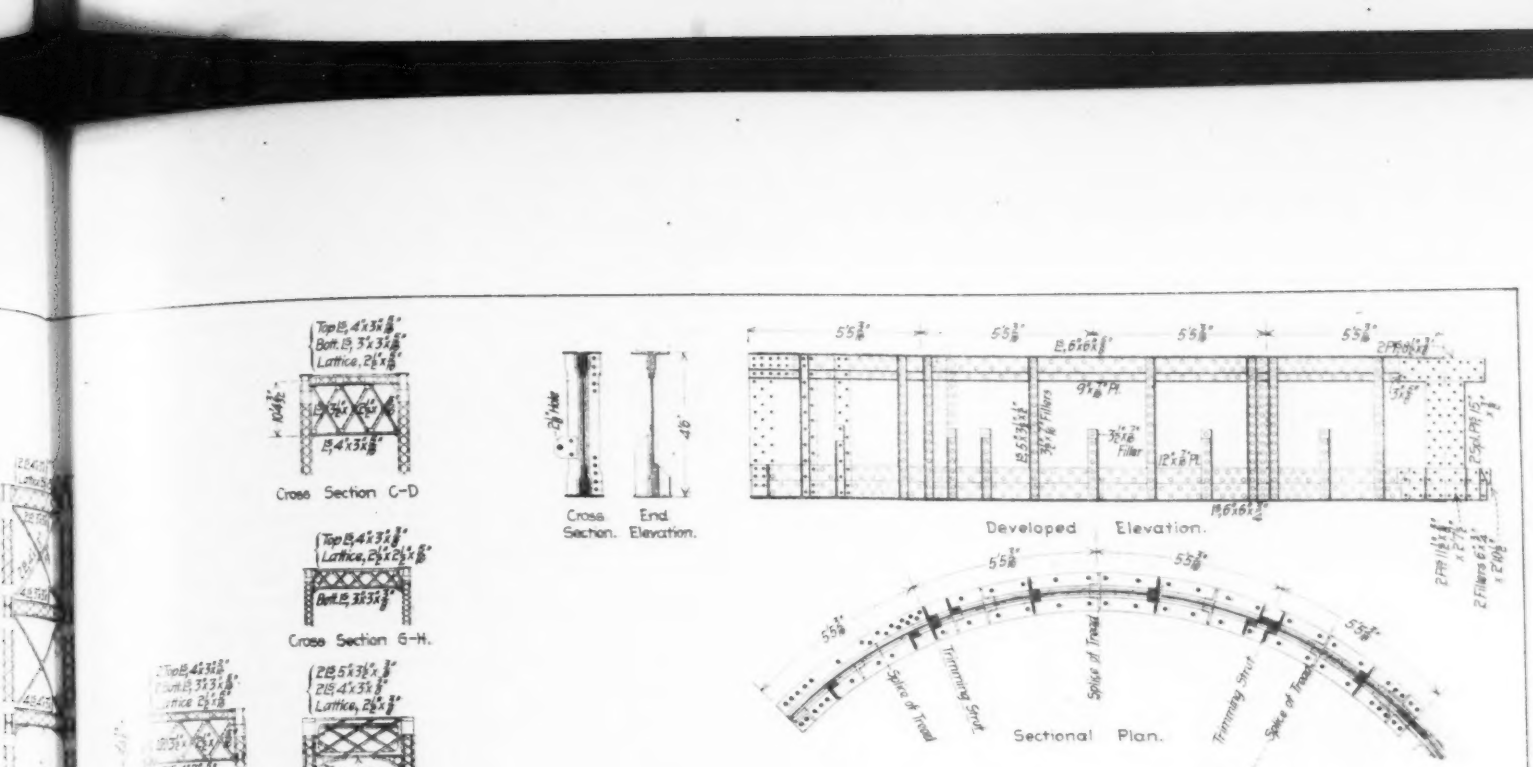


FIG. 10. RADIAL STRUT, CENTER HUB CASTING AND COLLARS FOR TURNTABLE DRUM.

MISSISSIPPI RIVER BRIDGE AT ROCK ISLAND, ILL., (DAVENPO

C. F. Loweth, M. Am. Soc. C. E., St. Paul, Minn., Chief Engineer.



NTABLE DRUM.

ILL., (DAVENPORT, ROCK ISLAND & NORTHWESTERN RY.)

Phoenix Bridge Co., Phoenixville, Pa., Contractors for Superstructure.

CHAS. HART, LITH., 26 VESEY ST., N. Y.

sons and property, also amounted each year to an enormous sum of money.

In the spring of 1889, the area within the limits of the city of Chicago (as it then existed) was about 44 square miles, and in July of the same year, by annexation of the towns of Hyde Park, Lake, Cicero, Calumet and Lake View, 130 square miles additional were added to the corporate limits of the city. The ordinance that was passed by the city council regulating the speed of railway trains within the city limits then came into force in the annexed territory, and the suburban residents who had their places of business within the old limits were delayed in getting to their work in the morning and returning to their homes in the evening. This part of the community then commenced to clamor and complain and hold mass meetings demanding more rapid transit. As such increase in speed and facilities would naturally increase the danger to life and property at the numerous street crossings at grade, the aldermen representing the different wards of the city were compelled to devise some means to bring about the best and most permanent manner of relief. Several ways were considered and discussed in which to abolish the grade crossings of railways at the intersection of streets, and the first step toward the exercise of compulsion in the matter was the passage of the "O'Neill ordinance," of Feb. 23, 1893. This ordinance, providing for the comprehensive elevation of tracks within a short period of time, was drawn up by Mr. John O'Neill, then an alderman, and now Superintendent of Track Elevation for some years. It has been used ever since as a means by which to try to compel railway companies to elevate their tracks, and has aided very largely in inducing the railway companies to accept track elevation ordinances which have been subsequently passed by the city, although the burden of cost was all put upon them. In the long run, however, the companies have been benefited, since they can operate their trains faster and with much greater regularity, while they are not subject to the damage, expense and public denunciation incident to grade crossing accidents. They are also free from the expenses of maintaining gates and men at all the crossings.

The map which accompanies the article in another column shows the complicated system of railways entering Chicago, with the location of the portions which have been elevated or depressed, or which are provided for under existing ordinances. It may be noted that some of the railways parallel each other on the same right of way, while the Chicago & Western Indiana R. R. is a terminal line leased by a large number of railways.

The first piece of track elevation under these ordinances was that done in 1892 by the Illinois Central R. R., from 47th St. to 71st St., to provide safe and rapid accommodation for the enormous traffic of the Columbian Exposition in 1893. At the present time, about 45 miles of railway have been elevated by different lines, but as these railways have from two to six or eight, and even ten tracks, the total length of single main track elevated is about 165 miles. Besides this, the work has included the raising of extensive freight yards, aggregating some 60 miles of track, so that the total amount of tracks elevated is about 225 miles. In addition to all this, about three miles of railway have been depressed, removing about 60 miles of tracks below the street surface, so that in all nearly 50 miles of railway with 228 miles of main track and 280 miles of all tracks have been permanently removed from the street level, eliminating 272 grade crossings.

There have now been passed by the city council, ordinances for the further elevation of the Chicago & Alton R. R., the Atchison, Topeka & Santa Fe Ry., the Chicago, Madison & Northern R. R., and others, including about 8 miles of road, with 29.23 miles of single main track, or an aggregate of all tracks in this system of about 45 miles, which will eliminate 56 grade crossings. An ordinance has also been passed for the Chicago & Western Indiana R. R. and Pittsburg, Fort Wayne & Chicago Ry., which comprises about 4 miles of road, with 45 miles of single main track elevation, or an aggregate of over 100 miles of track (including yards), and eliminating 78 grade crossings. This will practically consummate the main work of track elevation, with the exception of certain extensions and some other railways which are of minor importance, but which will be forced to elevate their tracks to complete the system of elevation as planned. When the work contemplated in the last two ordinances is completed, the railways will have elevated about 60 miles of road, with 280 miles of main track and 573.5 miles of main tracks, sidings and yards, and will have eliminated about 406 grade crossings. For many of the figures given above we are indebted to Mr. John O'Neill, Superintendent of Track Elevation.

The following table shows the length of lines and length of main tracks elevated on the several railways exclusive of yard track mileage:

Track Elevation in Chicago.

Track Elevation.	Length of line, miles.	Length of main track, miles.	No. of crossings eliminated.	No. of subways built.
A., T. & S. F. Ry.	1.75	3.50	..	..
C. & Alton R. R.	0.65	0.65	..	..
C. & N. W. Ry.	14.85	60.00	150	93
C., B. & Q. R. R.	2.75	11.00	14	16
C., M. & St. P. Ry.	8.40	18.30	33	29
C., R. I. & P. Ry. and L. S. & M. S. Ry.	5.50	22.00	32	32
C., R. I. & P. Ry. (alone)	1.80	3.60	15	14
L. S. & M. S. Ry. (alone)	0.90	1.80	2	3
Ill. Central R. R.	3.00	30.00	19	26
C., M. & N. Ry.	1.00	2.00	..	..
St. C. Air Line	1.25	2.50	3	3
P., C., C. & St. L. Ry. (1.30 miles, included in C. & N. W. Ry.	..	..	..	..
P., Ft. W. & C. Ry.	2.50	10.00	15	15
Total elevation	44.35	165.35	283	234
Track Depression.				
A., T. & S. F. Ry. and C. & W. I. R. R.	0.50	10.00	2	2
C., M. & St. P. Ry.	0.50	0.50	..	..
Ill. Central R. R.	2.00	52.00	..	..
Total depression	3.00	62.50	2	2
Total work done to date	47.35	227.85	285	236
Work Provided For.				
A., T. & S. F. Ry. and C., M. & N. Ry.	2.84	12.23	56	40
C. & Alton R. R.	4.50	13.50		
P., C. C. & St. L. Ry., C. T. T. R. R., and U. St. Yds. Co.	1.27	3.50		
P., Ft. W. & C. Ry., C. & W. L. R. R., Gd. T. Ry., and U. S. Yds. Co.	4.00	16.00	75	75
Total work provided for	12.61	45.23	131	115
Total work done and provided for	59.96	273.08	416	351

Any slight discrepancies which may occur in the figures are probably due to amendments to the several ordinances, by which the number of subways may be modified, or the length of line slightly changed by shifting the points of commencing and ending the elevation. These amendments are made in nearly every case, so as to meet the desires of the residents and of the railway companies. The mileage of yard tracks, also, it is impossible to state with any close exactness.

In 1892 a grade crossing commission was appointed by the mayor, and this commission in its report recommended the removal of all railway tracks from the area bounded by State, Canal, Madison and 22d Sts. In view of the great business and railway interests along the river, and of the very large suburban business of the three terminal stations within this area, such a plan would have been very inconvenient, and would have entailed an extra fare twice a day upon a large majority of the passengers. A general system of depressing the tracks was not practicable, owing to the flat and low-lying position of the city's site. A system of general elevation was therefore adopted, combined with a depression of the streets so as to reduce the height of elevation necessary. On Feb. 23, 1893, the council unanimously passed the O'Neill ordinance, providing that all steam railways must be elevated by Jan. 1, 1899, but this was superseded by later specific ordinances for the different roads on different portions of the terminal system. When it was seen that the work would have to be done, most of the railways accepted the situation, though some have continued to fight it. A list of the earlier ordinances was given in our issue of Aug. 18, 1898.

Three elevated railways have had to be raised at the points where they cross railways whose tracks have been elevated. The work on the Metropolitan Elevated Ry. was described in our issue of Sept. 30, 1897. The Lake St. Elevated Ry. required less work. On the South Side Elevated Ry. the new grades are steeper, and the total elevation was 11½ ft., which was obtained by riveting extensions to the columns, instead of raising the columns on masonry piers, as on the Metropolitan Ry. The work on the three lines was done by the Kelly-Atkinson Construction Co., of Chicago.

Several hundred subways have had to be built, all of practically the same general design, with stone or concrete abutments supporting plate girder through bridges, which either span the entire opening or are supported by steel columns at the curb line. A subway built under the old surface line of the Chicago & Northwestern Ry. at Sacramento Ave. was described in our issue of Sept. 21, 1893.

Where retaining walls are used to support the filling, they are usually of large dimension stone, like the abutments, although the Pittsburg, Fort Wayne & Chicago Ry. has used small dimension stone. Where the elevated lines are in the outlying districts no retaining walls are used as a rule. As to the use of concrete and stone masonry, the Chicago & Northwestern Ry. uses concrete for foundations of the rubble retaining walls, as it is cheaper, more rapidly built, and is more durable than Lemont limestone rubble at the ground line. Stone is used for the walls and abutments partly because the company owns and operates a quarry of its own. At the 16th St. crossing, concrete was used for all walls and abutments on account of the facility of construction, the circumscribed character of the location and the constant traffic, which, in combination, made it practically impossible to put up the rigging for handling large dimension stone. Concrete was also considered far preferable to small dimension stone. On the Chicago, Milwaukee & St. Paul Ry., concrete was adopted for walls and abutments on account of its cheapness, its durability and the facility of construction, but it is claimed that the Chicago & Northwestern Ry. did more rapid work in building stone abutments than the C., M. & St. P. Ry. did with concrete. The concrete cost about $4.90 per cu. yd. of wall, including forms. The Chicago, Burlington & Quincy R. R. adopted Indiana limestone on account of its durability.

The bridge floors are practically of two classes: (1) the trough floor; (2) the I-beam floor, with deck plating. Ballasted floors are exceptional, but have the advantage of being practically noiseless. This is shown by the subways under the P., Ft. W. & C. Ry., where this system of construction is used, and where only a slight rumbling is heard as the trains pass overhead. With the rails attached to the floor system, there is a loud thundering sound which is very unpleasant to persons living in the neighborhood and which is very apt to alarm horses, especially when they are passing through the subway.

As to the cost, it has been difficult to obtain figures, and itemized prices for details of the work are withheld by the railway companies. From official sources, however, we have obtained the totals given below, which include the work complete, with main and side tracks, yards, stations, approaches, masonry, bridge work, earthwork, etc. From these figures it will be seen that 47.5 miles of line and 228 miles of track elevated and depressed, have cost about $10,580,000. This gives a rough average of $222,737 per mile of line, and $46,403 per mile of track. The figures given in the following table represent the cost of work on the individual lines, independent of the amounts paid for joint work, such as the 16th St. crossing, the C., M. & N. Ry. and the St. Charles Air Line. The additional work called for by existing ordinances will bring the total up to about 60 miles of line, with 280 miles of main track, at a total cost of $15,000,000. This work will include the elevation of extensive freight yards.

A., T. & S. F. Ry. (included in 16th St. crossing)	.....
C. & N. W. Ry. (completed)	$2,840,070
C., B. & Q. Ry. (to Aug. 31, 1899)	423,848
C., M. & St. P. Ry. (to Oct. 1, 1899)	651,187
C., R. I. & P. Ry. (to March 31, 1899)	1,157,145
Ill. Central Ry. (including the St. Charles Air Line and C., M. & N. Ry.), all completed	1,915,000
L. S. & M. S. Ry. (to Oct. 1, 1899)	1,600,000
P., C., C. & St. L. Ry.) (completed)	292,000
P., Ft.W. & C. Ry. (51st St. to Grand Crossing)	1,200,000
Sixteenth St. Crossing (completed)	500,000
	$10,579,250

These figures, however, are far below the actual amounts expended, for the report of Mr. John O'Neill, Superintendent of Track Elevation, for the

year 1899, shows that the expenditures of all work done and provided for are estimated at $23,000,000, of which $17,000,000 had been expended by Dec. 31, 1899, leaving a balance of $6,000,000 for the work not yet completed under the existing ordinances. An abstract of Mr. O'Neill's report is given in another column.

Since the problem of abolishing grade crossings was first tackled in earnest, about eight years ago, we have kept our readers informed as to the methods taken to provide a satisfactory solution of the problem, and as to the execution of individual works. Articles and editorials on the general subject and on the earlier stages of the work will be found in our issues of July 21, 1892; March 9, 1893; April 26, 1894; July 19, 1894; and June 23, 1896. In another column of this issue we commence the description of the extent and character of the work done by each railway company on the Chicago track elevation system. Chicago is not the only place where the grade problem has been solved by compelling the railways to elevate or depress their tracks, and we have published various articles descriptive of the work at Boston, Brockton, Newton, Elizabeth, Jersey City, Buffalo, Philadelphia, etc. In none of these cases, however, has the track system involved been so complicated or of such extent as that of Chicago, nor have the lines crossed so many streets with heavy traffic. The conditions existing at Buffalo approach probably nearest to those existing at Chicago, but in most other cases the work has been confined to a line of railway passing directly through the city.

LETTERS TO THE EDITOR.

The Discharge of the Great Lakes; Correction.

Sir: We are much pleased with the able and complimentary manner in which the report of the Deep Waterways Board is reviewed in the last issue of Engineering News. I note, however, that you draw the conclusion that the discharge of the Great Lakes has been diminishing since 1867. We did not intend to convey that idea in our discussion, for with the same cross-section and head at the outlet of Lake Erie the discharge per mean stage has necessarily been constant. The change of volume of discharge stated is due to more accurate method of measuring velocity of flow. Very truly yours,

Geo. Y. Wisner.

Detroit, Mich., Jan. 6, 1900.

Depositing Concrete Under Water.

Sir: I am told by a representative of a bridge firm that concrete can be successfully placed in position in quiet water in the following manner: The materials are mixed dry and thrown into the water with a shovel, care being taken that they do not separate to any extent before striking the surface and that they enter it in a vertical direction. They then sink into position, the sand and cement finding their way into the spaces between the stones, which reach the bottom first. The ordinary precautions are taken to maintain level courses, etc. It is proposed to use this method in about 35 ft. of water in building a bridge pier with steel shell. I would like to know if this is considered good practice. Respectfully,

Shreveport, La., Jan. 3, 1900. T. M. M.

(The bridge building firm owning the representative who gave the information above referred to had better tie him up, quick. Anyone can deposit concrete through 35 ft. of water in a steel shell and fill it up in time; but the stuff in the bottom will be rip-rap and not concrete. If rip-rap is sufficient, better put it in in the first place and save the cement; but if concrete is wanted it should be lowered in buckets of approved construction. See Eng. News, March 17, 1898, and Dec. 21, 1899.—Ed.)

Should the General Manager Go?

Sir: Is there any railroad system having several general superintendents who all report to one president, direct, and not through the medium of a general manager?

What is to be said for and against such a method of administration? Would the labor of having to receive the reports of a few general superintendents make the president of a railroad system very tired? Would not this line of responsibility raise the tone of the road, by bringing all the subordinates as closely into touch with the president as is possible, and making them feel that he is interested in what they do? With a general manager between the president and the men on the road he is to them simply an abstraction, far away and vague as a mirage?

New York, Jan. 6, 1900. Track Walker.

(It all depends. Some Presidents hold their offices because of their extensive ownership in the corporation and their salaries are in the nature of perquisites, not payments for actual administrative services. Others actually perform the work of General Managers. On the large systems there is work enough and to spare for both President and General Manager. The President of a great railway system who should attempt to undertake also the administrative detail of a General Manager's office, would merely demonstrate his own unfitness for either position.—Ed.)

Some Convenient Rules for Engineers' Calculations.

Sir: It has occurred to me that possibly one or other of the accompanying rules might be of convenience to some of your readers, as they have been to me:

To find angles of deflection, or to change bearings to a new meridian, and for other purposes, it is frequently of advantage first to change the readings of the courses so as to refer their angles all to the same end of the meridian. Thus, assigning positive direction to the north end and positive revolution to counter clock-wise motion, the following courses will make with the meridian the angles given in the second column. The third column then gives the deflection angles by the following:

Rule.—To find the deflection at any station, subtract from the angle of that course the angle of the preceding course. A positive sign will indicate deflection to the left; negative to the right.

1.	S. 22° E.	$\pi + 22°$	$-64°$
2.	S. 62½° W.	$\pi - 62½°$	$-84½°$
3.	N. 7° E.	$-7°$	$\pi + 55½°$
4.	N. 1½° E.	$-1½°$	$5½°$
5.	S. 86° E.	$\pi + 86°$	$\pi + 87½°$

If a new line is to become the meridian, the deflections of the given courses from it may be ascertained by the above rule, and thus converted into bearings. The deflection in this case is found by the rule: Subtract the angle of the new meridian from the angle of each course for the deflection of that course. Thus, if the original bearing of the new meridian is N. 10° W., the deflections from it and the bearings of the above courses will be:

1. $\pi + 12°$	S. 12° E.	4. $-11½°$	N. 11½° E.
2. $\pi - 72½°$	S. 72½° W.	5. $\pi + 76°$	S. 76° E.
3. $-17°$	N. 17° E.		

Time and labor may be saved also in the calculation of double longitudes by making use of the arithmetical complement, thus avoiding subtraction. If L denotes double longitude, and d, departure, the familiar rule for finding L is exhibited in the third column below, where every L is obtained from the preceding L by adding to it the two d's between which it stands. If the departures of a survey are as in the second column, the actual work will be as in the fourth:

1.	1.55	d_1	1.55
2.	1.28	L_1	1.55
3.	1.86	d_2	1.28
4.	−2.00	L_2	4.38
5.	−2.69	d_3	1.86
		L_3	7.52
		d_4	$\bar{1}$ 8.00
		L_4	7.38
		d_5	$\bar{1}$ 7.31
		L_5	2.69

The following is a convenient rule for finding the number of barrels in a cylindrical vessel, with 32 gallons to the barrel, and $\pi = 3.1416$; h = height; r = radius:

$$C = \pi r^2 h,$$
$$= r^2 h \frac{2^2 \cdot 3^4 \cdot 7 \cdot 11 \cdot 0.0017}{2^5 \cdot 3 \cdot 7 \cdot 11},$$
$$= r^2 h \cdot 0.7344,$$
$$= \tfrac{3}{4} r^2 h - \frac{2}{100} r^2 h.$$
$$= r^2 h \frac{3.1416 \cdot 12^2}{231 \cdot 32},$$
$$= r^2 h\, 2^4 \cdot 3^2 \cdot 0.0017,$$
$$= r^2 h\, (0.75 - 0.02),$$

Hence the rule: Take three-fourths of the product, $r^2 h$; for greater accuracy, subtract from this 2 for every 100 in $r^2 h$; for still greater accuracy, add 4 for every 1,000, and 4 for every 10,000 in $r^2 h$, r and h are given in feet.

To convert miles per hour into feet per second, increase the number of miles by one-third of itself, and this again by one-tenth of itself. Thus: 60 miles per hour is equivalent to 60 + 20 + 8 = 88 ft. per second. If m is the number of miles per hour, and f the number of feet per second:

$$f = \frac{5{,}280}{60.60} m, \quad = \frac{2^4 \cdot 3 \cdot 11}{2^3 \cdot 3^2 \cdot 5} m, \quad = \frac{2 \cdot 11}{3 \cdot 5} m,$$
$$= m + \tfrac{1}{5} m + \tfrac{1}{10} (m + \tfrac{1}{5} m).$$

Also, since

$$m = \frac{3.5}{2.11} f, \quad = \frac{15}{22} f, \quad = \frac{14}{21} f, \text{ nearly,}$$
$$\therefore m = \tfrac{2}{3} f, \text{ nearly.}$$

Hence, to convert feet per second into miles per hour, approximately, multiply by ⅔. Respectfully,

Oscar Schmiedel,
Professor of Mathematics, Bethany College.
Bethany, W. Va., Dec. 9, 1899.

Notes and Queries.

W. W. P. writes:

Can you give me the names of any cities in New England or the Atlantic States in which one official performs the duties of both City Engineer and Superintendent of Streets; and do you know if such a combination of offices has resulted beneficially?

J. A. (Elk Rapids, Mich.), asks where he can obtain reliable information as to the cost of erecting cheap village and country houses of Portland cement concrete, and the cost of the same class of structures built of brick.

THE DAVENPORT AND ROCK ISLAND BRIDGE OVER THE MISSISSIPPI RIVER.

(With two-page plate.)

Introduction.

We illustrate in the accompanying cuts and on our two-page plate this week the general details of the latest bridge to be constructed across the Mississippi River. Some of our readers, perhaps, will also remember that this is the second railway bridge to be built across the Mississippi at Rock Island within the past five years. The Rock Island railway bridge previously erected was fully described in Engineering News of Dec. 17, 1896.

FIG. 2.—GENERAL VIEW OF MISSISSIPPI RIVER BRIDGE FOR DAVENPORT, ROCK ISLAND & NORTHWESTERN RY.

This bridge replaced an iron bridge built in 1872, and this older bridge had in its turn taken the place of a wooden Howe truss bridge which was completed in 1853, and which was the first bridge constructed over the Mississippi River. The new bridge, which we describe, is, therefore, the fourth bridge to span the Father of Waters at Rock Island.

History.—The history of the new bridge is a somewhat checkered one. In March, 1885, a few business men of Davenport, Rock Island and Moline, formed a company named the Davenport & Rock Island Bridge Co., and obtained from Congress an act or charter authorizing the construction of a railway bridge over the Mississippi River, between Davenport, Ia., and Rock Island, Ill. Nothing further appears to have been accomplished except to make a few surveys, and the matter dragged until 1895, when the project was taken in hand by Mr. F. P. Blair, of St. Paul, Minn., who, after several abortive attempts in

1895 and 1896, to begin construction, finally completed the necessary financial arrangements for the completion of the bridge and its connecting railway terminals.

During 1895 and 1896 several contracts for the substructure were entered into, but actual work was not begun until April, 1896. After the river abutment on the Rock Island side, and a portion of the substructure for the adjoining approach viaduct were completed, financial difficulties arose, and the work was abandoned. A new contract was made and work was resumed in September, 1896, and the first river pier was nearly completed, when the work was again discontinued. The year 1896 was not favorable for ventures of this nature. In September, 1897, a new contract for the construction of the river piers was made and actual work was begun late that same month on the completion of the first river pier, and the work thenceforth progressed continuously until its final completion. The name of the company was early changed to the Davenport & Rock Island Bridge, Railway & Terminal Co., and later to the Davenport, Rock Island & Northwestern Ry. Co.

Purpose.—The "Tri-Cities" of Davenport, Ia., and Rock Island and Moline, Ill., lying contiguous to each other, have a combined population of about 60,000, and constitute perhaps the most important shipping center on the Mississippi River, between St. Louis and St. Paul. Five distinct railway lines enter the cities, only one of which, the Chicago, Rock Island & Pacific Ry., has its own bridge over the Mississippi River, this company having a joint interest in the government bridge at this point. The new bridge forms a part of an extensive project for a belt and terminal railway within the three cities, and connecting with all the present railways. The company lately absorbed the Davenport, Clinton & Eastern Ry., and is now building a line from Davenport to Clinton, Ia.

Location.—The new bridge is located about 1½ miles below the government, or C., R. I. & P. Ry. bridge, and near the lower limits of the cities of Davenport and Rock Island. The main channel of the river at this point is about 2,200 ft. wide from the Rock Island shore to Island 310; on the west of the island is a slough about 600 ft. in width. Island 310 is about 300 ft. wide, and is overflowed during high water.

The ground necessary for tracks and yards in Rock Island was largely given to the company by the city, and was along the river bank. The tracks of the Rock Island & Peoria Ry. being also along the river bank, it was impracticable to approach the bridge at right angles with the river, and this end of the bridge had necesarily to be curved; the curvature extending to the draw span. The location of the draw span was determined by the War Department, in the interests of navigation, and was fixed at 600 ft. from the Rock Island shore, and this distance was divided into three spans of 200 ft. each. The clearance above high-water, and consequently the elevation of the track over the navigable portion of the river, was likewise determined by the War Department. These conditions made necessary a total curvature at the Rock Island end of the bridge of about 80°. That portion on the embankment and the approach viaduct is an 8° curve, and that over the three 200-ft. spans is 7° and 6° 30′ curves, with a 0.6% ascending grade to the end of the bridge, and thence a gradually decreasing grade over the three 200-ft. spans.

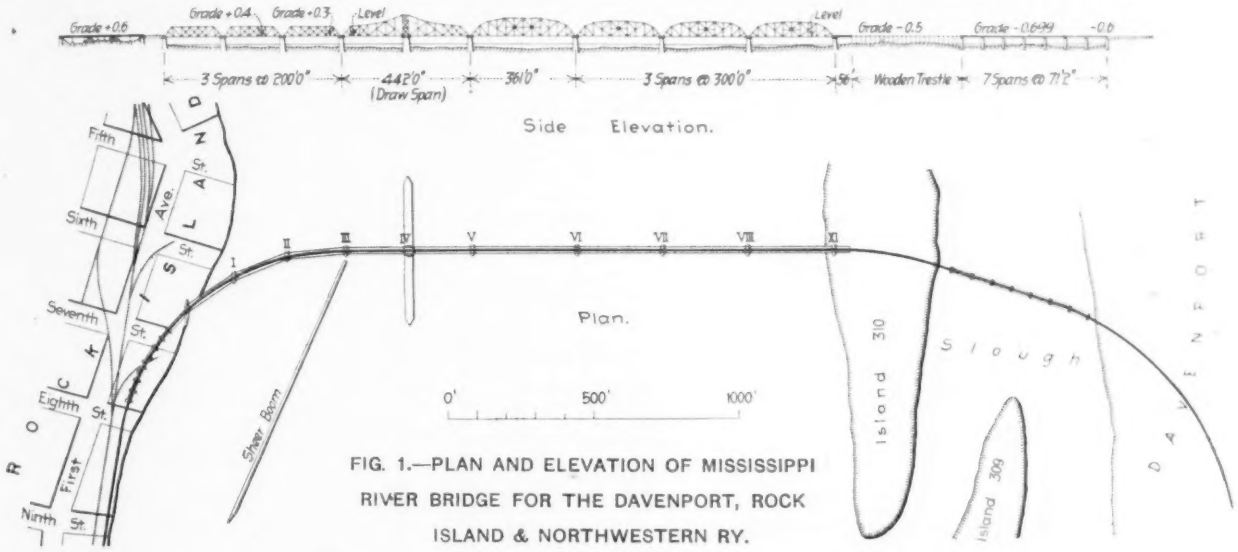


FIG. 1.—PLAN AND ELEVATION OF MISSISSIPPI RIVER BRIDGE FOR THE DAVENPORT, ROCK ISLAND & NORTHWESTERN RY.

C. F. Loweth, M. Am. Soc. C. E., St. Paul, Minn., Chief Engineer.

Phoenix Bridge Co., Phoenixville, Pa., Contractors for Superstructure.

About 100 ft. from the Rock Island end of the bridge a viaduct was required to cross over Seventh St., and two coal tracks of the Rock Island & Peoria Ry. This structure is 278 ft. in length, is made up of 30 to 50-ft. skew girder spans, and is on an 8° curve and 0.6% grade. The river bridge, beginning at the Rock Island end, comprises three spans of 200 ft. each, a swing span of 442 ft., one span of 365 ft., three of 300 ft., and one 56-ft. approach girder span at the island shore. The Davenport approach, beginning at the bridge, comprises 380 ft. of pile trestle over Island 310, seven deck plate girder spans of 72 ft. each across the slough, and 630 ft. of pile trestle. All of this approach is on a 6° curve to the right, except four of the 72-ft. spans. The long curves at each end of the bridge, and both in the same direction, led to the structure being called the "Crescent Bridge." This peculiarity of the plan and the various other general features described are clearly shown by the general plan and elevation, Fig. 1. Fig. 2 is a view of the river portion of the bridge from the Rock Island shore. This view was taken just previous to the acceptance of the work from the builders in March, 1899, and does not show the electric wiring and the bridge tender's house. With the preliminary description given these illustrations give a clear idea of the location and character of the bridge.

Substructure.

The substructure for the river bridge proper consists of nine piers of first-class ashlar masonry. Fig. 3 shows a representative pier for the fixed span work, and Fig. 4 shows the general details of the pivot pier for the swing span.

The masonry is of what is known locally as Anamosa limestone. The stone came mostly from the quarries of F. Erickson & Co., of Stone City, Ia., about 84 miles from the bridge site, and was shipped by rail, except the starlings or ice-breaks, which are built of gray granite from St. Cloud, Minn. The courses vary from 14 to 28 ins. in thickness. The starlings are made of three stones in each course, all securely dowelled. The belt and coping courses were each dowelled to the next lower course and the coping further secured with heavy cramps. Portland cement mortar, made with either Alpha or Atlas cements, was used for all work under water, for the starlings, and for setting the coping and belting courses. For the balance of the work Utica cement was used.

The abutments and first three piers from the Illinois side were founded on bed rock. The other six piers are on piles, cut off at the river bed or lower. The foundations of the three piers next the Iowa side were made in open cofferdams, concrete being placed over and above the piles. The three midchannel piers have timber grillages on the piles.

The river piers are 7 ft. 6 ins. in width, and 31 ft. in length under the belting course, and 2 ft. wider at the coping. The sides batter ½-in. per foot, and the starlings batter along the shoulder lines 9 ins. to each foot in height, except for the first pier on the Illinois side, where this batter is but 6 ins. per foot of height. The lower ends of the piers are circular and the upstream ends are formed by two arcs of a radius equal to the width of the pier, and intersecting at the center. The center pier for the draw span is 32 ft. in diameter on the coping. The piers in the Davenport slough, carrying the 72-ft. girder spans, are steel cylinders, filled with piles and concrete, and securely braced together with solid webs. The downstream protection pier for draw span is a pile and timber structure, while the upstream protection pier is a timber crib 26 ft. wide, and 250 ft. in length, filled with stone. This crib was framed together as a whole near the shore, and when built up as high as the depth of water would permit was towed into place, and sunk on to a bed of rip-rap deposited on the quite compact gravel river bottom, and brought up to a depth of 7 ft. below low water level. The total height of the crib is 27 ft., and the sides of the upstream end make an angle of 45° with the long side of crib making the angle of the nose 90°, and it is battered back 6 ins. to each foot of height. The entire upstream end is protected by old railway rails, thoroughly bolted to the wood work, the spaces between the rails being filled with Portland cement mortar, making a cheap, substantial and very satisfactory protection against ice. The rails used were practically scrap, and were procured in 28-ft. lengths. Their original weight was 56 lbs. per yard. They were spaced 5 ins. apart, and spiked on each side in the ordinary way to each horizontal course of the crib timbers. In addition they were secured by drift bolts through holes drilled in both sides of the base, so as to afford additional resistance to overturning. Several of the rails on each side of the nose and at the shoulders were bolted together through their webs. There was required by the War Department a sheer-boom, 1,000 ft. in length, extending up stream from the draw opening adjoining the Illinois shore. On account of

its exposed location it was necessary to make this a floating boom, which will be taken in at the close of navigation each fall, and put in place again in the spring. This structure is built solid, 9 ft. wide and 3 ft. thick, of 4-in. thick planking, alternate diagonal and longitudinal layers, and in three lengths of 333 ft. 4 ins. each. It has a substantial fence or guard 5 ft. high on the river side, and is securely anchored in position.

Mr. Chas. Stone, of St. Paul, Minn., had the contract for the river piers and their foundations, including some 4,490 cu. yds. of masonry, besides concrete, piling, etc. A contract was awarded for the draw span protection piers and Davenport slough cylinder piers, but it was abandoned by the contractors soon after beginning work, and this work was finished by the railway company by day's labor.

Superstructure.

General.—The superstructure of the bridge consists of a 442-ft. swing span and 7 fixed spans (three 200 ft., three 300 ft., one 361 ft.), composing the main river bridge and of seven 71 ft. 2-in. spans over the Davenport slough, besides the miscellaneous steelwork in the viaduct approaches on the Rock Island shore. The metal work of the superstructure is of rolled steel throughout, except the cast iron bolsters under ends of spans and cast steel rollers, tracks, and other details of the swing span.

The trusses were proportioned for Cooper's Class E 35 typical train load; the floor beams, stringers, and suspenders being proportioned for Class E 40 loading. The plans for the work were made in the railway company's office under the personal supervision of the Chief Engineer, Mr. C. F. Loweth, M. Am. Soc. C. E., and designed in accordance with Cooper's specifications, 1896 edition. The outlines of the spans are shown by Fig. 1. The 200-ft. span with curved track, have trusses spaced 23 ft. apart centers, the others are spaced 18 ft. 6 ins. apart; the panel lengths vary from 28 ft. in the 200-ft. spans, to 30 ft. 1 in. in the 365-ft. spans. The super-elevation of the outer rail where curved track occurs on the bridge was obtained by elevating the outer line of track stringers. The track is made up of 8 × 10-in. southern pine ties, spaced about 12 ins. centers. Every third tie is 16 ft. in length and the balance are 12 ft. long. There are wooden guard rails 8×8 ins. notched over the ties and spaced 10 ft. apart centers, also inside guards of 4×4×⅝-in. steel angles, which are bolted to each tie, and are spaced 10 ins. from the gage side of the rails. These guard angles were not a part of the superstructure contract.

361-ft. Fixed Span.—The longest of the fixed spans is that immediately adjacent to the swing span on the Iowa side. This span is 361 ft. c. to c. of end pins, and is divided into 12 panels, each 30 ft. 1 in. long. Fig. 5 shows a half elevation and half top and bottom plans of the span. These drawings indicate clearly the general composition of the various members, which are, with one or two exceptions, of ordinary construction not requiring detailed illustration. A distinctly unusual feature is that there are adjustable rods extending from the lateral plates at the feet of alternate vertical posts to the chord pins in the adjoining panels. These rods are used only in the lower chord tension member panels, and their purpose is to relieve the vertical posts and hangers of the component of bottom lateral strain parallel with the chords. The elevation and bottom plan in Fig. 5 indicate the construction. As the lateral connection is made at the level of the foot of the post and the bottom of the beams, or 9 ins., below the center of the chord, there would be a large bending moment in the post from the pin upward unless this provision was made. Another detail of this span which merits mention is the end bearing construction, which is clearly shown in Fig. 6. It will be noted that the bolsters, made of I-beams, are the full width of the pier so as to relieve the masonry of any horizontal strain due to expansion and contraction of the spans. It will also be noted that while there are cast-iron separators between these I-beams the spaces between the beams are filled solid with Portland cement mortar, thus abundantly guarding against any tendency of the bolsters to collapse. The total weight of the span is 1,039,091 lbs.

300-ft. Fixed Spans.—Except in their dimensions and those details affected by their different dimensions, the 300-ft. spans resemble in construction the 361-ft. spans just described. From center to center of end pins these spans are 296 ft. long, and are divided into twelve panels 29 ft. 7¼ ins. each. From center to center of piers the span length is 300 ft. The total weight of each span is 742,438 lbs.

200-ft. Fixed Spans.—The three 200-ft. spans nearest the Illinois shore differ in the form of truss employed from the other fixed spans, and, of course in those details influenced by the form and smaller dimensions of the trusses. Generally speaking, however, the construction is similar to that already described for the larger fixed spans. The total weight of the three spans is 1,239,685 lbs.

Swing Span.—General elevations and plans of the swing span are shown in Fig. 7. As will be seen, it is of the familiar central tower and suspended truss type commonly employed in America. The drawings show the calculated strains and the adopted composition of all of the principal members. Except that the span has the unusual feature of having its outer ends carried by expansion rollers, it calls for no further explanation than is given by the drawings, Fig. 7. The expansion bearings are entirely separate from the end lifting mechanism. The span is carried on a rim bearing turntable.

The weight of the span is distributed onto the turntable drum by means of two distributing girders running transversely to the axis of the bridge, as shown at A and B in the plan, Fig. 7. The construction of these girders in detail is shown by Fig. 8. Each of these girders was shipped assembled, and each weighed 76,000 lbs. The drum is 27 ft. 8 ins. in diameter. Its cylindrical portion is made up of four plate girder segments of the construction shown by Fig. 9. This plate girder cylinder is braced together radially by eight girders. The outer ends of these girders are riveted to the inside of the drum and their inner ends are riveted to a radial collar plate, which rides loose on a bearing near the top of the center hub casting. Another collar plate also riding on a bearing located lower down on the center hub casting, carries the inner ends of the 48 radial rods, to whose outer ends are journaled the rollers which form the roller ring on which the drum rotates. The wheels or rollers are of cast steel 18 ins. in diameter and 12½ ins. tread. These wheels run between a cast-steel track attached to the bottom of the drum and a cast-steel track 22 ins. wide and 9 ins. high resting on the center pier masonry. Fig. 10 shows the construction of the radial struts, center hub casting and collar plates which have just been referred to.

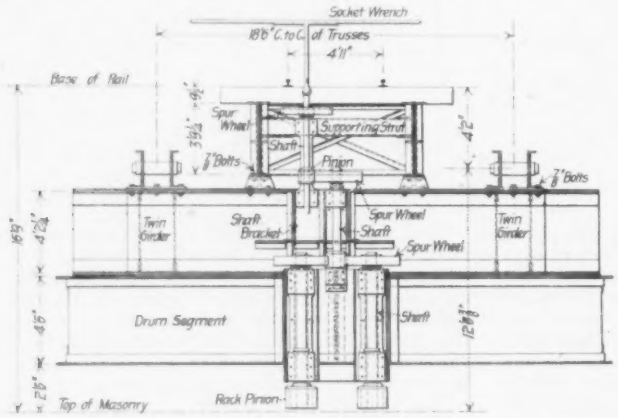


FIG. 11.—ELEVATION SHOWING ARRANGEMENT OF TURNING MECHANISM.

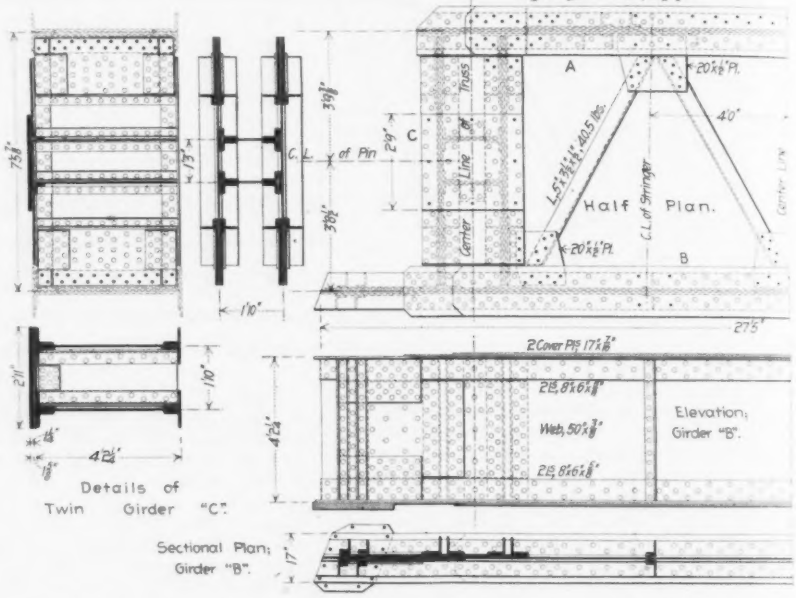


FIG. 8.—DETAILS OF TWIN DISTRIBUTING GIRDER, SWING SPAN.

The rotation of the drum and the swinging of the span which it carries is accomplished in the usual manner of rim bearing swing bridge turntables. The rack is of cast steel, with 10-in. face and 3 61-64-in. pitch, and is securely bolted to the outer edge of the center pier track casting. Attached to the drum are two pairs of turning shafts with their actuating mechanism, which are located diametrically opposite each other on the center line of the span. Fig. 11 shows one of these sets of machinery and the other is similar to it in all respects. On the end of the shaft A, which is operated by hand or motor as desired, is a pinion, B, which gears with the spur wheel C keyed to the shaft D. The shaft D carries in turn at its lower end the pinion E, which meshes with two spur wheels, F and G, on the driving shafts H and J. Shafts H and J carry the driving pinions K and L, which mesh with the rack on the center pier. Fig. 12 shows the details of the main driving shafts and pinions and the attachments for fastening them to the drum. The operation of the turning machinery is clearly shown by Fig. 11.

Fig. 13 shows the essential features of the end lifting and locking machinery. The end floor beams have two webs separated 14 ins. from each

other, between which most of the machinery for raising and locking is placed. Since the arrangements are the same at each end and symmetrical about the center of the floor beam, the machinery on one side of one end floor beam only need be described. In the center of the floor beam is a vertical shaft with a screw thread, and on it is a cross-head Z having a movement of nearly 2 ft. on vertical guides, Y. To the cross-head is connected a horizontal link X, 16 ins. long c. to c. of pin holes, by the pin W. The other end of this link is connected by the pin V to two triangular links, which turn upon the pin U. To pin V is connected a horizontal strut T, the other end of which is connected to two locking rollers S by the pin R. To the pin R are attached four links, P, the other ends of which are connected by means of pin O to steel castings N, bolted to the lower end chord. Returning now to the triangular links, it will be seen that they carry a link M, the upper end of which connects with the rail lift. By studying the mechanism just described it is easy to see how by rotating the vertical shaft and raising the cross-head Z the train of mechanism is set in operation which finally unlocks the ends of the bridge and raises the rails so that the whole may swing clear.

The swing span is turned, and the end adjustments operated, by four electric motors. The two motors for turning are each 30 HP. and have a speed of 600 revolutions per minute, and are located on a platform between the track stringers just outside of the drum. The two motors for the end lifts are each of 5 HP., and are located at the end of the bridge between the track stringers. They work the end adjustments of the bridge, including rail lifts, and have a speed of 850 revolutions per minute. A 500-volt direct current is used, and the speed of the motors is reduced through cast-steel gears. The motors are series wound, railway type, Crane motors. The apparatus for controlling the turning and lifting mechanism is in a small house at the center of the span and on a level with the track, so that the bridge tender is not obliged to climb a high flight of steps. Here are located separate controllers for both the turning and end lifting motors, and a switch board with necessary instruments. By a simple arrangement of the switches it is impossible for the attendant to put the current through both the turning and lifting motors at the same time. The electrical current is brought to the draw span by overhead wires. Electric lights are used for the signal lights required about the draw span and its protection piers, and all the wiring about the piers and bridge is enclosed in iron pipe conduits. The Westinghouse Electric & Manufacturing Co. furnished and installed all the electric work. The total weight of the draw span, including machinery, is 1,400,571 lbs.

Plate Girder Spans.—The plate girder spans in the approaches to the bridge number 15 altogether. Seven of these in the viaduct approach on the Rock Island side have spans of varying lengths, but aggregating 277.88 ft. The girders are spaced 12 ft. 2 ins. apart, and are 4 ft. 4½ ins. deep back to back of angles. The structure across the Davenport slough contains seven plate girder spans, each 71 ft. 2 ins. long. The girders are spaced 8 ft. apart, and are 7 ft. ¼-in. deep back to back of angles. The remaining plate girder span connects the trestle on Island 310 with the succeeding 300-ft. span. This span is 56 ft. long, and the girders are set 8 ft. apart and are 5½ ft. deep back to back of angles.

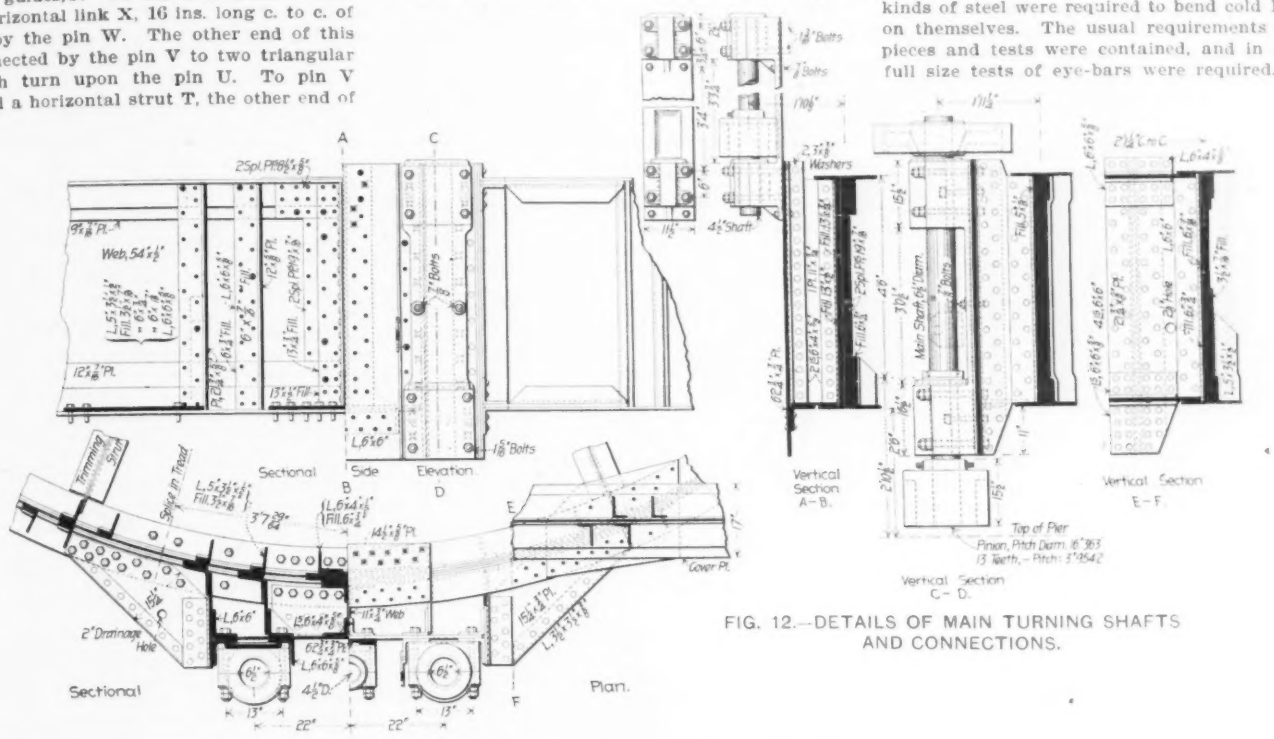


FIG. 12.—DETAILS OF MAIN TURNING SHAFTS AND CONNECTIONS.

Material.—The material used for the bridge was rolled steel throughout, except as follows: All field rivets were of wrought iron; the wheels, end bearings, rack and track segments, and pinions for the swing span were cast steel, and the other gearing, the turntable center, the boxes and bearings for the swing span machinery and the pedestals were of cast iron. All steel was required to be made by the open hearth process, and not to contain exceeding 0.07% of phosphorous when acid or 0.04% when basic. Rivet steel was required to have an ultimate strength of from 48,000 lbs. to 58,000 lbs. per sq. in., an elastic limit of not less than 0.55 of the ultimate strength, and an elongation of 26%. The ultimate strength of all other steel was to be from 60,000 lbs. to 70,000 lbs. per sq. in., its elastic limit was to be 0.55 of the ultimate strength, and its elongation was to be 22%. Specimens of both rivet steel and other kinds of steel were required to bend cold 180° flat on themselves. The usual requirements for test pieces and tests were contained, and in addition full size tests of eye-bars were required. These eye-bars were required to show not less than 10% elongation in the body of the bar and to have an ultimate strength not more than 5,000 lbs. below the minimum tensile strength required of specimen test pieces from steel of the same grade. The following shows the results of the tests of full size eye-bars:

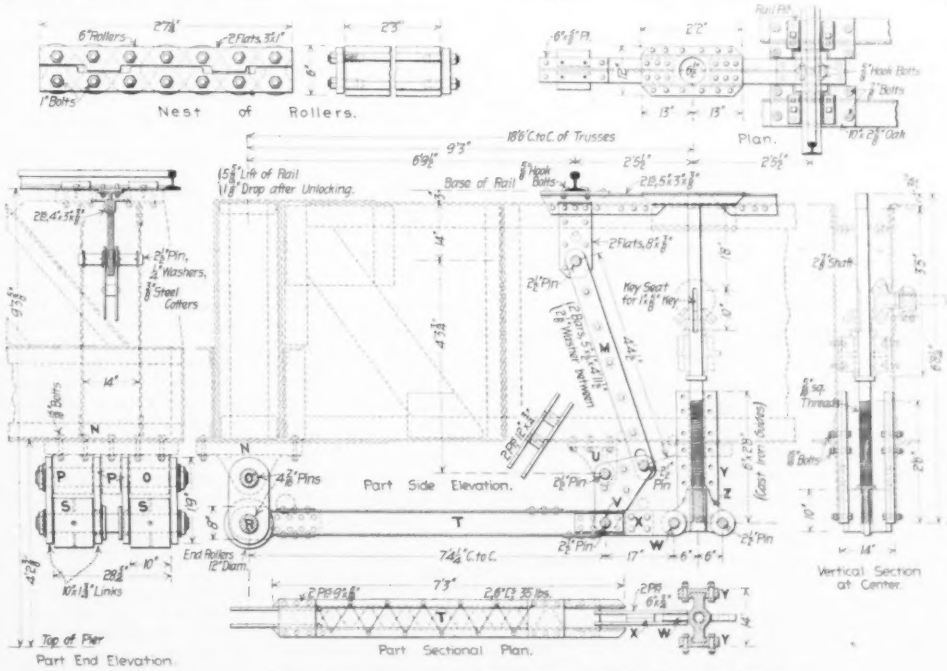


FIG. 13.—DETAILS OF END LIFTING AND LOCKING MACHINERY.

Size eye-bar, section in ins.	Elastic limit, lbs. per sq. in.	Ultimate strength, lbs. per sq. in.	Elongation. in 12 ins.	Elongation in gaged length.
8 × 2	33,210	58,580	..	14.22% in. 27 ft.
7 × 1 9-16	31,830	58,670	33	19.54% " 26 "
7 × 1⅛	32,850	58,860	37	12.16% " 25 "
6 × 1 9-16	31,010	54,120	41	15.5 % " 42 "
6 × 1 5-16	29,880	55,500	39	10.7 % " 25 "
6 × 1¼	34,980	60,980	38	13.74% " 38 "

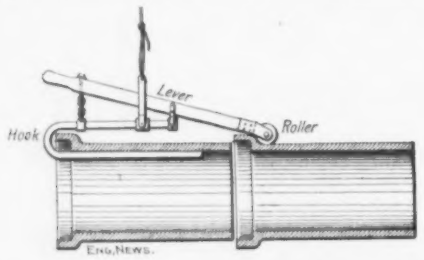
The other requirements for materials and those for workmanship were such as are usual in first-class practice, and require no mention in detail.

The foregoing describes quite fully the main structural features of the new Rock Island bridge. The engineer for the bridge was Mr. C. F. Loweth, M. Am. Soc. C. E., of St. Paul, Minn., and the contractors for the steel work were the Phoenix Bridge Co., of Phoenixville, Pa. The inspection and testing were conducted by Booth, Garrett & Blair, of Philadelphia, Pa., inspecting engineers. We are indebted to Mr. Loweth and to the Phoenix Bridge Co. for the information from which this description has been prepared.

THE PROSPERITY OF 1899 is indicated in many ways. The interest and dividends payable in January, 1900, are the largest known, and amount to $66,006,066 on securities valued at $3,246,389,832. Of this total interest, $34,747,995 is due on stocks. Taking into account, says the "Daily Stockholder," the various securities of banks, trust and insurance companies and other corporations a fair estimate of the January disbursements amounts to about $130,000,000. Another indication of prosperous conditions is the fact that in 1899 the gifts to educational, religious and charitable institutions amounted to $79,749,956, as compared with $23,984,900 in 1898, and $33,612,814 in 1897.

A PIPE-LAYING HOOK FOR SEWER WORK.

The device illustrated herewith is intended to facilitate the work of handling and setting sewer pipe in the trench. It consists of a common pipe hook, to which is attached a lever carrying a small roller, the device being attached to the rope used in lowering the pipe into the trench. The man on the surface fits the hook to the bell-end of the pipe, as shown in the cut, and lowers the pipe. The pipelayer takes hold of the end of the lever and raises it until the end of the pipe is clear of the ground and the spigot end clears the bell of the



last pipe laid. He then moves the lever forward, guided by the roller running on top of the pipe already laid, until the spigot has entered the bell of the latter pipe and is in proper position. This device facilitates the work, reduces the amount of pipes chipped or broken in laying, and secures better joints with either cement or jute packing, especially preventing the formation of "dams" made by squeezing the cement mortar of the joints up into the pipe.

This pipe-laying hook is a specialty made by the Berry Flush Tank Co., of Iowa City, Ia.

REPORT OF THE NEW JERSEY STATE SEWERAGE COMMISSION.

The New Jersey State Sewerage Commission is the successor to several other commissions appointed primarily to devise means for the prevention of the pollution of the Passaic River. The present Commission was created less than a year ago, and has a broader scope and more ample authority than its predecessors. The final disposal of sewage from all new sewerage systems in New Jersey is subject to the approval of the Commission; it is expected to collect information regarding the nature and extent of the sewerage systems of the State; and the law which established it gave it certain supervisory powers over joint sewerage systems built by several municipalities. No such systems, however, have been built during the past year. The Commission is also expected to investigate sewage purification in all its phases.

The work of the Commission has been greatly hampered by lack of an appropriation and lack of authority to remedy faults in the disposal methods of existing sewerage systems.

Up to the close of the last calendar year the Commission had approved the proposed outlet sewer for some of the Oranges, Millburn, part of Newark, and other municipalities, with discharge into tide water, this approval being conditioned upon the remedying of nuisances, if any such arise. It also disapproved the proposed discharge of the sewage of the State Reformatory at Rahway into the Rahway River. Aside from the evil effects of possible pollution of the river, the Commission felt that it was a pity for the State to set so bad an example.

The report points out the fact that the large amount of water waste in many cities and towns not only costs much money in itself, but increases the magnitude of the sewage disposal problem, as does the combined system of sewerage, where it exists.

A large part of the body of the report is devoted to the conditions in the valley of the lower Passaic, which were worse, the report states, in 1899 than ever before. The pollution of the river must be stopped. Possible means of prevention are one great trunk sewer from Paterson to Newark or New York Bay; individual purification works for each municipality; and the division of the section involved into three districts, the sewage from each of which would be treated separately. The Commission does not express a preference for any one of these plans, but urges that it be given money and authority to make a thorough study of the situation, so that it may decide upon their comparative merits. It also suggests that it be given power to receive and pass upon complaints of sewage pollution and "to conduct litigation and appear as complainant on its own motion," and that "the preservation of water supplies from pollution should be placed under its control, with adequate legislation to meet the gravest necessities of the case."

Accompanying the report are statistics regarding the sewerage systems of New Jersey. The report is signed by the five commissioners, as follows: Wm. T. Hunt, Chairman; John Hinchliffe, Chas. F. Harrington, Chas. W. Fuller, and David L. Wallace.

The report is a very creditable one, conservative yet progressive, and containing many valuable suggestions. It is very desirable that the powers and duties of the Commission be extended along the lines suggested, and also that it be given a liberal appropriation to carry on the work which has been so long delayed, and which cannot fail to be of immense advantage to the whole commonwealth, if pursued with intelligence.

MUNICIPAL ENGINEERING IN CHICAGO.*

I see by the program that I am expected to speak on "Municipal Engineering." Had I been consulted, I would have asked to have the subject changed to read "Engineering Municipal Engineers." Before attempting to "talk shop," however, I wish to testify to the faithful, zealous and intelligent conduct of the engineers of the city in promoting and protecting her interests. I am proud to have the opportunity to say this to the Western Society of Engineers, because I want to ask the members of this society to lend their trained minds as citizens to aid in solving many of the problems that must be solved to redeem the city from a position of ridicule before the world.

There are conditions in this city which must be discussed candidly and honestly. We must not try to deceive ourselves while we praise ourselves to the outside world. While we have been most unfortunate in being led into a condition that requires such radical changes, it may, like other great disasters, in the end prove a blessing. Perhaps the complete destruction of the temporary improvements that have been made from time to time in the development of this city would provide an opportunity for the presentation of a broad plan for the building of Chicago on such a scale of perfection that we might say to the world that Chicago is what the desire of every citizen wishes it to be, the most perfect in every appointment of its municipal improvements, and the most desirable to live in of any city in the world.

The engineering work to be done in this city should be done with reference to a completed city in every detail. Its roads, its walks, its bridges, its water service, its sewer service—all are in such condition as to require the best thoughts of the best minds in this city, and I know of no body of men better equipped to undertake that duty for Chicago than the Western Society of Engineers. The duties devolving on you as citizens require that you should step outside of the usual lines of employment, and at least give to this city (which has provided opportunity for so many engineers) the benefit of your best thoughts in formulating plans, in the execution of which many engineers will certainly receive benefit.

There is not a question entering into the necessities of the city from an engineering standpoint on which there is not a great difference of opinion. There was a period when our center-pier bridges were considered monuments to the administration that had supervision of their construction. The day has come when the center-pier bridge has become a nuisance, an obstruction to navigation and a hindrance to securing the much desired advantage of pure water. Our center-pier bridges to-day stand as a menace to the future of Chicago. Many types of bridges have been presented for the consideration of the authorities, but there is no one type of bridge that has yet been accepted as being entirely satisfactory for the purpose of securing passage over the Chicago River, accommodating transportation and cheapening the cost of operation and maintenance. In that line alone, therefore, there is eminent opportunity for the genius of the engineer.

The question of pavement is one that is agitating Chicago, as it is agitating every city in the world. No pavement that has been experimented with (and every pavement appears to be an experiment) is satisfactory from all standpoints. While London and Paris are removing the asphalt pavements, we are now laying them. For one, however, I am not advocating them. In my official capacity I propose to move along with the demands of the community, because I must confess I have nothing better to offer. Brick pavements are being presented as a sort of substitute, because they are a little cheaper in first cost.

Recently one great stride has been made in the laying of the pavement, and that is the requirement for a more permanent foundation. A change was recently made from the use of natural to Portland cement. It increased the cost. The engineers connected with the city recommended the change because of the failure to secure success with the original foundations. The wisdom of the step, however, is disputed.

Referring to the improved and more expensive foundation, brings me to a subject that is all important, since we are laying this expensive construction, specially in the business section. To-day we lay a pavement over a number of gas mains that are defective or are of insufficient capacity; over water mains that were laid years ago when the requirements of this section were not one-tenth of what they are to-day; over sewers that were built for three, four and five-story buildings, where the floor capacity and the demands on them were not one-tenth of what they are to-day. Evidently in such cases we shall see the tearing up of the pavements in the very near future for the purpose of reconstructing the underground work. And with the many interests in that underground work, unless steps are taken in this city to provide a general subway system through all the main streets of the business section, it will be almost impossible to harmonize all of these interests so that they may work together to promote the placing of permanent pavements in the business section of Chicago. I regard that as the greatest question of the day, so far as the business portion of Chicago is concerned.

The Illinois Telephone Co. recently received permission to excavate the streets for the purpose of placing wires in the ground. When they sought the place in the ground to place their wires they could not find it in the ordinary location, and they were compelled to excavate at a greater depth. They asked for and secured permission to construct a tunnel 25 ft. below the streets. I reluctantly signed that permit, because I had in mind that the very location secured by that corporation was a space the value of which cannot be estimated by any man living to-day. It should have been preserved by this municipality for a great underground structure that would accommodate every single interest that enters into the streets and requires the removement of the pavement.

Now, as to the question of drainage and the work undertaken by the municipality for diverting the flow of sewage from the lakes to the channel, I was one of the citizens who believed that work should have been completed by the Trustees of the Sanitary District. The City council of the city, however, believed otherwise, and Council of the city, however, believed otherwise, and authorized that a Commission be appointed to formulate a plan to submit to the municipality for its consideration and approval and adoption that would utilize the canal that was constructed at such a great expenditure. I believe that every gentleman that constituted that Commission was a member of the Western Society of Engineers, except one. The plan submitted by the Commission known as the Pure Water Commission is to-day being executed, with but few changes, and these consisted in an enlargement of the main conduits to secure the dilution of sewage so that it would not be necessary for the Sanitary Trustees to build conduits parallel to the conduits or sewers being built by the city.

The progress of that work has not been all that we could wish, but the character of the work is everything that

*Abstract of an address delivered by Mr. L. E. McGann, Commissioner of Public Works, at the annual banquet of the Western Society of Engineers, Jan. 2, 1900.

could be expected, and the success of the undertaking is assured. So that in the near future, in addition to diverting the flow of the sewage that is now deposited in the Chicago River, every sewer emptying directly into Lake Michigan will have been diverted so that the sewage will be carried to the Drainage Canal.

There is no reason why we should fall back into the old temporary mushroom improvements that we have had here in the past years. While the names of Cregier and Chesbrough will be revered by every citizen of Chicago who knows how broadly they planned and what values they gave to Chicago, and what little return Chicago ever gave to them, there is still an opportunity for a modern engineer to exercise his broad intelligence and devise plans and execute them on the same board, comprehensive scale that will secure in this city the erection and completion of improvements co-extensive with the desires of this city, and that will be a credit to the engineering profession

This is the broad scheme that I believe the members of the Western Society of Engineers should advocate, not necessarily for their own opportunity, but to extend to your fellow citizens the blessings that are given you by your training and genius, in return for the opportunity given you in this community.

THE WATER PURIFICATION PLANT AT ALBANY, N. Y.

The time has passed when our larger cities can use as an apology for failure to provide pure water the plea that water purification is still in an experimental stage and that no large plants for that purpose have ever been built in this country. The excuse has long been a weak one at best, in view of the purification works of various sorts and sizes which have been in use for a number of years past in America, and of the large plants so common abroad.

Within the past year a number of additional cities have completed or begun the construction of filtration plants notable on account of their size and excellent design. The largest American city now receiving water which has been subjected to a thorough process of purification is Albany, N. Y., and the plant furnishing this water is also the largest water purification plant in this country. It has now been in continuous operation since early in September, 1899. At its normal working rate of 3,000,000 gallons per acre per day the capacity of the Albany plant is 16,800,000 gallons per day when all of the eight beds are in service and 14,700,000 gallons when one is out of use for cleaning. As the water is not normally turbid and as the 5.6 acres of filter beds are supplemented by a settling reservoir having a capacity of about 15,000,000 gallons, the percentage of idleness for any part of the plant should be quite small. It seems fair, therefore, to credit the plant with a daily capacity of 16,000,000 to 17,000,000 gallons, at least until its operations show a different result.

The Albany plant and its construction were pretty fully described and illustrated in Engineering News of Feb. 10, and Oct. 20, 1898. Since then the plant has been completed, subjected to the practical test of operation for a number of months and officially described in detail by the engineer who designed it and superintended its construction, Mr. Allen Hazen, Assoc. M. Am. Soc. C. E. This description was presented to the American Society of Civil Engineers at its meeting on Jan. 3, and was supplemented by figures relating to the operation of the plant, carefully prepared by Mr. Geo. I. Bailey, M. Am. Soc. C. E., Superintendent of the water-works of Albany. Some features of the plant not fully described in our previous articles will be presented here, together with an abstract of the discussion by Mr. Bailey and others.*

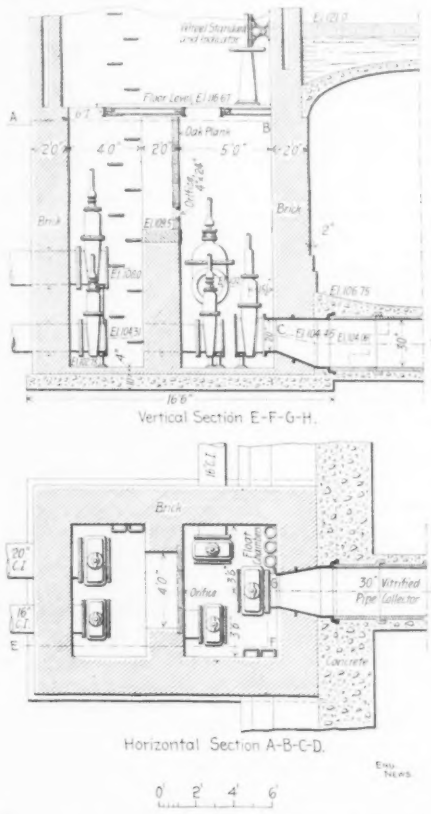
The filters are covered with groined masonry vaulting of concrete, supported by brick piers, and have a floor of inverted concrete masonry arches, also groined. There is also a clear water reservoir, 94 ft. sq., holding 600,000 gallons, which has a masonry roof. The sedimentation reservoir has been mentioned.

The underdrainage system was very carefully designed to produce low velocities and small friction, in order to diminish the loss of head and keep the rate of filtration as nearly equal as possible at near and remote points. The frictional resistance of the sand itself to the water's flow, is designed to be 50 mm. (1.97 ins.), when the filter is working at 3,000,000 gallons per acre per day and when the sand bed is clean. "The friction of the underdrainage system is estimated at 10 mm." The underdrains are 6-in. vitrified pipe, "laid with a space of about 1 in. between the barrels, leaving a large opening for the admission of water from the gravel."

An adjustable float and balanced valve shuts off the water when it reaches the desired height on each filter. In case this device fails to act an overflow comes into use to serve the same purpose.

The filter outlets and some other related features of the plant are described in Mr. Hazen's paper substantially as follows:

Filter Outlets.—The outlet of each filter is through a 20-in. gate controlled by a standard graduated to show the



Plan and Section of Regulator Chamber, Albany Water Purification Plant.

exact distance the gate is open. The water rises in a chamber and flows through an orifice in a brass plate, 4 by 24 ins., the center of which is 1 ft. below the level of the sand line. (See plan and section of regulating chamber reproduced from our issue of Feb. 10, 1898, with some details added.—Ed.) At the nominal rate of filtration, 3,000,000 galls. per acre daily, 1 ft. of head is required to force the water through the orifice. With other rates the head increases or decreases approximately as the square of the rate and forms a measure of it. With water standing in the lower chamber, so that the orifice is submerged, it is assumed that the same rates will be obtained with a given difference in level between the water on the two sides of the orifice, as from an equal head above the center of the orifice when discharging into air.

Measurement of Effluent.—In order to show the rate of filtration two floats are connected with the water on the two sides of the orifice. These floats are counterbalanced; one carries a graduated scale and the other a marker which moves in front of the scale and shows the rate of filtration corresponding to the difference in level of the water on the two sides. When the water in the lower chamber falls below the center of the orifice, the water in the float chamber is, nevertheless, maintained at this level. This is accomplished by making the lower part of the tube water-tight, with openings just at the desired level, so that when the water falls below this point in the outer chamber it does not fall in the float chamber.

To prevent the loss of water in the float chamber by evaporation, or from other causes, a lead pipe is brought from the other chamber and supplies a driblet of water to it constantly; this overflows through the openings, and maintains the water level at precisely the desired point. The floats thus indicate the difference in water level on the two sides of the orifice whenever the water in the lower chamber is above the center of the orifice; otherwise, they indicate the height of water in the upper chamber above the center of the orifice, regardless of the water level in the lower chamber. The scale is graduated to show the rates of filtration in millions of gallons per acre of filtering area. In computing this scale the area of the filters is taken as 0.7 acre and the coefficient of discharge as 0.61.

At the ordinary rates of filtration the errors introduced by the different conditions under which the orifice operates will rarely amount to as much as 100,000 galls. per acre, or 1-30 of the ordinary rate of filtration.

Measurement of Loss of Head.—Two other floats with similar connections show the difference in level between the water standing on the filter and the water in the main drain pipe back of the gate, or, in other words, the frictional resistance of the filter, including the drains. This is commonly called the loss of head, and increases from 0.2 ft. or less, with a perfectly clean filter, to 4 ft. with the filter ready for cleaning. When the loss of head exceeds 4 ft. the rate of filtration cannot be maintained at 3,000,000 galls. per acre daily with the outlet devices provided, and, in order to maintain the rate, the filter must be cleaned.

Adjustment of Gages.—The adjustment of the gages showing the rate of filtration and loss of head is extremely simple. When a filter is put in service the gates from the lower chamber to the pure-water reservoir and to the drain are closed, the outlet of the filter opened, and both chambers allowed to fill to the level of the water on the filter. The length of the wire carrying the gage is then adjusted, so that the gage will make the desired run without hitting at either end, and then the marker is adjusted. As both the rate of filtration and loss of head are zero under these conditions, it is only necessary to set the markers to read zero on the gages to adjust them. The gates can then be opened for regular operation, and the readings on the gages will be correct. It is necessary to use wires which are light, flexible, and which will not stretch. At first piano wire, No. 27 B. & S. gage, was used, and was well adapted to the purpose, except that it rusted rapidly. Because of the rusting it was found necessary to substitute another wire, and cold-drawn copper wire, No. 24 B. & S. gage, was used with fair results. Stretching is less serious than it would otherwise be, as the correctness of the adjustment can be observed and corrected readily every time a filter is out of service.

The outlets of the filters are connected in pairs, so that filtered water can be used for filling the underdrains and sand of the filters from below prior to starting, thus avoiding the disturbance which results from bringing dirty water upon the sand of a filter not filled with water.

All parts of the piping and regulating systems of the purification works proper are large enough to permit of 50% increase, over the normal rate of filtration, which is 3,000,000 gallons an acre, or 14,700,000 gallons per day for the whole plant when one filter is out of use. The low lift pumping station and connections with the purification works and the 48-in. steel pipe line from the clear water reservoir to the main pumping station each has a capacity of 25,000,000 gallons a day. The latter capacity, however, is not likely to be often reached at the pumping station, since it can be effected only by using old reserve pumps of 10,000,000 gallons nominal capacity, which are so very uneconomical in operation that they are never used if it can be avoided, reliance being placed on Allis pumps of 15,000,000 gallons capacity. From the main station the water is pumped to reservoirs holding 37,000,000 gallons, which gives sufficient storage capacity to permit the suspension of pumping "for considerable periods if necessary, and in practice it has been suspended at certain times, especially on Sundays."

A larger clear water basin than the present one, which has a capacity of 600,000 gallons, only an "hour's supply at the full nominal rate," would have been desirable, but local conditions were unfavorable for its construction. The capacity of the storage reservoirs being thus limited, storage at the filters was deemed necessary, but only to such an extent as will "allow the pumps to be started at the convenience of the engineer, and give a reasonable length of time for the filters to be brought into operation." The capacity of the pure water reservoir serves this purpose, but it can do no more. Further provisions against abnormal variations in the rate of filtration and against overworking the filters are described, and an interesting discussion of English and German practice in this respect is given in Mr. Hazen's paper, as follows:

Method of Regulating and Changing the Rate of Filtration.—With all the Allis pumps running at their nominal capacity, the quantity of water required will just about equal the nominal capacity of the filters. When only one or two pumps are running, the rate of filtration can be reduced. With the plant operating up to its full capacity, the water level in the pure-water reservoir will be below the level of the standard orifices in the filter outlets. When the rate of pumping is reduced, if no

*For the full official description of the plant, see Proc. Am.. Soc. C. E., Nov., 1899.

change is made in the gates controlling the filter outlets, the water will gradually rise in the pure-water reservoir and in the various regulator chambers, and will submerge the orifices and gradually reduce the head on the filters, and consequently the rates of filtration, until those rates equal the quantity pumped. In case the pumping is stopped altogether, the filters will keep on delivering at gradually reduced rates until the water level in the pure-water reservoir reaches that of the water on the filters.

When the pumps are started up, after such stoppage or reduced rate of pumping, the water levels in the pure-water reservoir and in the gate chambers will be lowered gradually, and the filters will start to operate at first with extremely low rates, which will increase gradually until the water is depressed below the orifices, when they will again reach the rates at which they were last set. The regulators during all this time will show the rate of filtration on each filter, and, if any inequalities occur which demand correction, the gates on the various outlets can be adjusted accordingly.

The arrangement, in this respect, combines some of the features of the English and German plants. In the English plants the filters are usually connected directly with the clear-water basin, and that in turn with the pumps, and the speed of filtration is required to respond to the speed of the pumps, increasing and decreasing with it, being regulated at all times by the height of water in the pure-water reservoir. This arrangement has been subject to severe criticism, because the rate of filtration fluctuates with the consumption, and especially because the rates of filtration obtained simultaneously in different filters may be different. There was no way to determine at what rate any individual filter was working, and there was always a tendency for a freshly scraped filter to operate much more rapidly than those which had not been scraped for some time.

This led to the procedure, first formulated by the Commission of German Water-Works Engineers in 1894, and provided for in most of the German works built or remodeled since that time, of providing pure-water storage sufficient in amount to make the rate of filtration entirely independent of the operation of the pumps. Each filter was to be controlled by itself, be independent of the others, and deliver its water into a pure-water reservoir lower than itself, so that it could never be affected by backwater, and so large that there would never be a demand for sudden changes in the rate of filtration.

This procedure has given excellent results in the German works; but it leads oftentimes to expensive construction. It involves, in the first place, a much greater loss of head in passing through the works, because the pure-water reservoir must be lower than the filters, and the cost of the pure-water reservoir is increased greatly because of its large size. The regulation of the filters is put upon the attendants entirely, or upon automatic devices, and regulation by what is known as "responding to the pumps" is eliminated.

More recently, the German authorities have shown less disposition to insist rigidly upon the principles advanced in 1894. In a compilation of the results of several years' experience with German water filters, Dr. Pannwiz* makes a statement of particular interest, of which a free translation is as follows:

> Most of the German works have sufficient pure-water reservoir capacity to balance the normal fluctuations in consumption, so that the rate of filtration is at least independent of the hourly fluctuations in consumption. Of especial importance is the superficial area of the pure-water reservoir. If it is sufficiently large there is no objection to allowing the water level in it to rise to that of the water upon the filters. With very low rates of consumption during the night the filters may work slowly and even stop, without damage to the sediment layers when the stopping and starting take place slowly and regularly, because of the ample reservoir area.
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> The very considerable fluctuations from day to day, especially those arising from unusual and unforeseen occurrences, are not provided for entirely by even very large and well-arranged reservoirs. To provide for these without causing shock, the rate of filtration must be changed carefully and gradually, and the first essential to success is a good regulation apparatus.
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> "Responding to the pumps" has a great deal to recommend it. It allows the pure-water reservoir to be put at the highest possible level, it reduces to a minimum the loss of head in the plant, and yet provides automatically, and without the slightest trouble on the part of the attendants, for the delivery of the required quantity of water by the filters at all times. If the filters are connected directly to the pumps there is a tendency for the pulsations of the pumps to disturb their operation, which is highly objectionable, even if the pumps are far removed; and this exists where filters are connected directly to the pumps, and a pure-water reservoir is attached to them indirectly. By taking all the water through the pure-water reservoir and having no connection except through it, this condition is absolutely avoided, and the pull on the filters is at all times perfectly steady.
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> Much has been said as to the effect of variation in the rate of filtration upon the efficiency of filters. Experiments have been made at Lawrence and elsewhere which have shown that, as long as the maximum rate does not exceed a proper one, and under reasonable regulations, and with the filter in all respects in good order, no marked decrease in efficiency results from moderate fluctuations in rate. There is probably a greater decrease of efficiency by stopping the filter altogether, especially if it is done suddenly, than by simply reducing the rate. The former sometimes results in loosening air bubbles in the sand, which rise to the surface and cause disturbances, but this is not often caused by simple change in rate.
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> On the whole, there is little evidence to show that, within reasonable limits, fluctuations in rate are objectionable, or should be excluded entirely, especially in such cases as at Albany, where arrangements to prevent them would have resulted in very greatly increased first cost. The inferior results sometimes obtained with the system of "responding to the pumps" as it existed in earlier works, and still exists in many important places, undoubtedly arises from the fact that there is no means of knowing and controlling the simultaneous rate of filtration in different filters, and that one filter may be filtering two or three times as fast as another, with nothing to indicate it.
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> This contingency is fully provided for in the Albany plant. The orifices are of such size that even with a filter just scraped and put in service, with the minimum loss of head, with the outlet gate wide open, and with the water level in the pure-water reservoir clear down; that is, with the most unfavorable conditions which could possibly exist, the rate of filtration cannot exceed 5,000,000 or 6,000,000 galls. per acre daily, or double the nominal rate. This rate, while much too high for a filter which has just been cleaned, is not nearly as high as was possible, and in fact actually occurred in the old Stralau filters at Berlin, and in many English works; and, further, such a condition could only occur through the gross negligence of the attendants, because the rate of filtration is indicated clearly at all times by the gages. These regulating devices have been specially designed to show the rate with unmistakable clearness, so that no attendant, however stupid, can make an error by an incorrect computation from the gage heights. It is believed that the advantage of clearness by this procedure is much more important than any increased accuracy which might be secured by refinements in the method of computation, which should take into account variations in the value of the coefficient of discharge, but which would render direct readings impossible.

*"Arbeiten aus dem Kaiserlichen Gesundheitsampte," Vol. XIV., p. 260.

The total cost of the purification works at Albany, including the intake, low-lift pumping station, piping at the plant and nearly 8,000 ft. of 48 in. steel pipe encased in concrete, was about $500,000, of which some $90,000 was for the conduit. The $500,000 includes about $28,000 for engineering, inspection and printing and $8,200 for land. Omitting the last two items, the approximate cost of the sedimentation basin was $60,000; pure water reservoir, $9,000; and the filters, $255,000; or $4,100 per 1,000,000 gallons of settling basin and $45,600 per acre of net filtering area. The estimated cost of the whole work was $478,000. The 4% of excess cost was due to the fact that the pumping station was "made more elaborate and expensive" than at first proposed and to encasing the conduit in concrete.

Mr. Bailey, whose name has already been mentioned as the superintendent of the Albany works, followed the reading of Mr. Hazen's paper by an account of the operations of the plant for the last four months of 1899. The total cost of 1,470,000,000 gallons (net) of filtered water was $6,165, or $4.19 per 1,000,000 gallons, including the cost of washing the sand and the water used for that purpose. The force employed was as follows: One foreman at $2.75 per day; ten laborers at $1.50; one watchman at $1.50; one chemist at $1,000 a year; three engineers at $75, and three firemen at $60 per month. The engineers, laborers and firemen work only eight hours a day. The low lift pumping expenses account for $2.52 of the cost of $4.19 per 1,000,000 gallons, leaving $1.67 for operating the filters, including laboratory expenses. Scraping, wheeling and washing the sand cost $1.13 of the $1.67 per 1,000,000 gallons for operating the filters. The filters were scraped three times during the four months. From 12 to 14 volumes of water to one of sand were required for washing the latter by means of the ejector sand washing machines described in our issue of Feb. 10, 1898.

Bacterial results for the 17 weeks ending Dec. 30 are given in the accompanying table.

The average bacterial removal for the whole period is 99.1%. The average color of the raw water on the platinum scale was 5.6, of which about 40% was removed. The turbidity was reduced to a very low figure. The effect of filtration upon the sanitary quality of the water seems to have been very marked, the deaths from typhoid fever during the four months since the filter was put in operation having been only 7, against 24 for the corresponding period a year ago.

Bacterial Results Obtained at the Albany Water Purification Plant.

Week ending.	Bacteria per cu. cm. in Raw water.	Bacteria per cu. cm. in Filtered water.	Per cent. removed.
Sept. 9	11,545	608	94.8
16	14,000	306	97.8
23	17,480	273	98.5
30	22,600	259	98.8
Oct. 7	18,760	250	98.7
14	11,900	178	98.5
21	3,930	85	99.1
28	4,700	84	98.4
Nov. 4	6,090	56	99.1
11	5,000	46	99.1
18	7,950	69	99.1
25	11,000	79	99.2
Dec. 2	19,240	109	99.4
9	20,000	198	99.1
16	57,700	142	99.7
23	66,000	327	99.5
30	48,900	215	99.6

Mr. W. B. Fuller, M. Am. Soc. C. E., Resident Engineer on construction, gave some details regarding the character of the work. He called attention to the fact that the masonry covering did not increase the cost of the plant so much as is often estimated, the total cost of the filters being at the rate of $45,600 per acre and of the vaulting some $13,600, or about 30%. Put differently, the covering added some 43% to the cost of the filters. In these figures the cost of land and engineering are not included.

The covering at Albany was thought necessary on account of the low winter temperatures. The range of temperatures for 22 years has been from +98° to —18°. Besides protection from freezing, the roof prevents the growth of algae on the surface of the filter beds, prevents baking of the surface and interference from rain and snow during scraping; lessens the friction in the sand due to changes in temperature; and prevents disturbance from wave action.

Mr. Geo. Hill, Assoc. M. Am. Soc. C. E., thought a saving of 20% in cost of roofing might have been effected by using concrete slabs, reinforced by expanded metal.

Lieut.-Col. A. M. Miller, M. Am. Soc. C. E., of Washington, D. C., said he had on his shoulders the preparation of estimates for a 60,000,000-gallon filtration plant.

In answer to a question by Mr. Rudolph Hering, M. Am. Soc. C. E., Mr. Bailey stated that about 12,500,000 of the 16,000,000 gallons of water supplied daily to Albany are filtered water, the balance being a gravity supply of very fair quality. The city owns about 35% of the drainage areas from which the gravity supply comes. Before the filtration plant was put in operation, about one-third of the city was supplied from the gravity sources, but only 9% of the typhoid fever was on this part of the supply.

A communication from Mr. C. E. Fowler, stated that experience with open filters at Poughkeepsie showed that algae caused as much trouble as ice. From May 1 to Oct. 1, the filters were scraped six times, while three would have been sufficient except for algae. The removal of algae really cost more than the removal of ice. Baking of the surface during scraping makes it necessary to remove three or four times as much sand towards night as in the morning. He would cover filters in any climate. He would never use filter units greater than those at Albany (0.7 acre) and smaller ones might be better. He would use a greater depth of gravel than at Albany (1 ft.).

Mr. Geo. W. Fuller, Assoc. M. Am. Soc. C. E., wrote that the upper, fine gravel layers seemed to be as thin as practicable; some engineers thought they were too thin. The cost of $45,600 per acre was much less than the cost of foreign plants. The conditions at Albany were favorable to low cost.

In closing the discussion, Mr. Hazen said that the thickness of the gravel was based on an experience of 12 years with experimental and other filters; and that care in screening and placing the gravel counted for more than mere depth. Several types of concrete and steel vaulting were considered, many were very attractive, but all were largely experimental and none assured any great saving. The water board was averse to having anything experimental about the plant.